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TECHNICAL MEMORANDUM

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South Cavalcade Superfund Site Human Health Risk Assessment
Houston, Texas

1. Introduction

On behalf of Beazer East, Inc. (Beazer), ARCADIS U.S. Inc. (ARCADIS) has prepared this Technical Memorandum presenting the results of a Human Health Risk Assessment (HHRA) for the South Cavalcade Superfund Site (Site) located in Houston, Texas. The HHRA has been completed to support the Technical Impractability Demonstration Report for the Site (Key Environmental, Inc. 2011).

The Site is located in Houston, Texas, and occupies approximately 66 acres between Cavalcade Street and Collingsworth Street along Maury Street (Figure 1). Recovery of dense non-aqueous phase liquid (DNAPL), enhanced by groundwater extraction to increase hydraulic gradients, was conducted at the Site from 1996 to 2006. Groundwater monitoring at the Site has shown that the extent of constituents in groundwater and their concentrations have stabilized. (Key Environmental, Inc. 2011)

The HHRA assesses potential current and future health risks associated with concentrations of constituents in groundwater to which people who work and live on and near the Site may potentially be exposed. This technical memorandum describes the groundwater data, constituents of potential concern (COPCs), toxicity assumptions, exposure scenarios and potential exposure assumptions that were used in the HHRA to evaluate the potential risks associated with the present and potential future uses of the Site.

2. Conceptual Site Model

Current land use of the Site is commercial/industrial. Three trucking companies utilize the Site and much of the Site is covered by pavement or buildings as shown on Figure 2-1 of the TI Demonstration Report (Key Environmental, Inc. 2011). Because affected groundwater plumes extend off the Site, potential exposure of both on-Site and off-Site receptors was estimated in the HHRA. The conceptual site model (CSM) includes two key factors that preclude certain exposure pathways. First, existing consent orders prohibit the use of on-Site groundwater as potable water. Thus, no potable use of on-Site groundwater by on-Site workers is possible. Second, a clean layer of groundwater with non-detectable concentrations of potentially volatile constituents exists at all locations between ground surface and groundwater with detectable levels of such constituents (at a depth of 16 to 20 feet below ground surface), except at on-Site source entry points (Key Environmental and Groundwater Insight 2000). This layer of clean groundwater prevents migration of volatiles from groundwater to indoor air in all off-Site locations. It also prevents migration of volatiles from groundwater to indoor air in all on-Site locations except at source entry points. Finally, this layer of clean groundwater also prevents potential exposure of on-Site and off-Site construction and utility workers to constituents in groundwater except at on-Site source entry points. Due to these limiting factors, incomplete pathways include:

- potential direct exposure to groundwater (i.e., via ingestion and dermal contact) for current and future on-Site workers;
- potential direct exposure to shallow groundwater (except at on-Site source entry points) for on-Site and off-Site construction and utility workers;
- the vapor intrusion pathway for current and future off-Site residences; and
- potential direct exposure to current off-Site residents.

Potentially complete pathways include:

- potential inhalation of indoor air for the current and future on-Site worker at the tire shop[1];
- potential direct contact with groundwater (both dermal and ingestion exposure routes) as well as inhalation of trench air for the future utility worker and excavation air for the future construction worker at on-Site source entry points; and

[1] The tire shop is located on the Palletized Trucking property within an inferred potential source area in the southeastern section of the Site. It is the only on-Site structure located within a potential source area that is occupied at ground level.

- potential direct contact (dermal and ingestion) as well as inhalation of shower air for a hypothetical future off-Site resident.

As discussed above, the presence of a layer of shallow clean groundwater precludes potential exposure of off-Site hypothetical future highway construction workers to constituents in groundwater via direct contact (both dermal and ingestion exposure routes) as well as inhalation of excavation air. However, to be conservative and account for the possibility of this shallow layer of clean groundwater being breached during construction of a highway, the potential risks of a hypothetical future highway construction worker potentially exposed to constituents in groundwater via direct contact (both dermal and ingestion exposure routes) as well as inhalation of excavation air are evaluated in the uncertainty section (Section 7) of this Technical Memorandum.

Note as well that assuming that direct contact exposure for the construction and utility worker may occur at on-Site source entry points is very conservative. The soil remedy for the Site consisted of the construction of concrete covers over the source areas and other potentially impacted soil areas to preclude contact with these areas. Any disturbance of the concrete covers would require the approval of the United States Environmental Protection Agency (USEPA). Additionally, concrete pavement (which the site owners are required to maintain) cover all other areas of potentially impacted surface soils. Given the recognition that these represent source entry points, personal protective equipment minimizing potential exposure would also likely be required for any subsurface work in these areas Thus, the presence of this cover makes it very unlikely that subsurface utility or construction work will occur in any of these areas.

As requested by the USEPA, the hypothetical future residential scenario includes exposure to both a child and adult resident. Figure 2 presents the CSM for the Site.

3. Summary of Data used in the HHRA and COPC Selection

To the extent possible this HHRA uses data collected from the most recent Site-wide groundwater investigations. The most recent available benzene and naphthalene data were collected from Site-wide wells in 2005[2]. The most recent Site-wide data for other volatile and semivolatile compounds, which included benzene, toluene, ethylbenzene, and xylenes (BTEX) and polycyclic aromatic hydrocarbons (PAHs), were collected in 1999 and 2000. Therefore, data collected from 1999 and 2000 were used to estimate groundwater concentrations for all constituents except benzene and naphthalene. Benzene and naphthalene concentrations were estimated based on 2005 data.

[2] Beazer recently completed a sampling event in March 2011; however, the analytical results are not yet available.

3.1 On-Site Groundwater

Well OW-02, sampled on December 14, 1999, is located in the northern section of the Site and is representative of constituent concentrations of groundwater in contact with source material at the Site. Table 2.1 presents a summary of all constituents that were detected in OW-02.

3.2 Off-Site Groundwater

To estimate potential exposures for the hypothetical future off-Site residential scenario, the well closest to existing residences, MW-26, was used. Concentrations of constituents for the evaluation of potential risks to the hypothetical future highway construction worker presented in the uncertainty section are based upon wells within the hypothetical future construction area (i.e., PSG-5, DPS-L1, DPS-L1, DPS-T0, DPS-TN1, DPS-TN2, DPS-TN3, DPS-TS1, DPS-TS2, DPS-TS3, MW-05, MW-08, MW-24, MW-25 (4/17/2000), MW-25 (7/5/2000), MW-25 (9/19/2005), MW-26 (4/17/2000), MW-26 (7/5/2000), MW-26 (9/19/2005), TW-10-1, TW-10-2, TW-2-1, TW-8-1, TW-9-1, and TW-9-2). Tables 2.2 and 2.3 summarize data from MW-26, and from wells within the hypothetical future construction area, respectively.

3.3 Identification of COPCs

Maximum groundwater concentrations were conservatively screened against the regional screening levels (RSLs) for tapwater. The RSLs are developed assuming exposure to tapwater via ingestion, dermal contact, and inhalation. If maximum concentrations of a constituent in on-Site and off-Site groundwater were below the RSLs, that constituent was not included as a COPC and was not retained in the HHRA.

4. Exposure Assessment

Reasonable Maximum Exposure (RME) scenarios were developed for all receptors included in the HHRA (i.e., current/future on-Site Worker, current/future on-Site Utility Worker, future on-Site Construction Worker, hypothetical future Highway Construction Worker, and hypothetical future off-Site Resident). The specific exposure pathways used to evaluate these scenarios are summarized below.

4.1 Current/Future On-Site Worker Scenario

A current on-Site Worker was assumed to potentially be exposed to COPCs in indoor air in the tire shop. Future on-Site workers are assumed to have potential exposures similar to those of current workers in the tire shop. Table 4.1.RME presents the potential exposure assumptions for the current on-Site Worker scenario.

4.2 Current/Future On-Site Utility Worker Scenario

Potential groundwater exposure pathways for current and future on-Site utility workers are assumed to be incomplete over the majority of the Site. A current/future on-Site Utility Worker was assumed to be exposed to COPCs in groundwater at source entry points. Data from shallow source area monitoring well OW-02 represents the constituent composition of groundwater in contact with source material at the Site. Potential exposure may occur in utility trenches via incidental ingestion and dermal contact as well as inhalation of volatilized COPCs in trench air. Tables 4.2.RME and 4.3.RME present the potential exposure assumptions for the current/future on-Site Utility Worker scenario.

4.3 Future On-Site Construction Worker Scenario

Potential groundwater exposure pathways for future on-Site construction workers are assumed to be incomplete over the majority of the Site. A future on-Site Construction Worker was assumed to be exposed to COPCs in groundwater at source entry points. Potential exposure may occur in excavated areas via incidental ingestion and dermal contact as well as inhalation of volatilized COPCs in air within the excavated area. Tables 4.2.RME and 4.3.RME present the potential exposure assumptions for the future on-Site Construction Worker scenario.

4.4 Hypothetical Future Off-Site Highway Construction Worker Scenario

As noted above, potential exposure pathways to constituents in groundwater are likely to be incomplete for off-Site hypothetical future highway construction workers. However, to be conservative this Technical Memorandum evaluates the potential exposures of a hypothetical future off-Site Highway Construction Worker in the uncertainty section. Hypothetical future off-Site Highway Construction Workers were assumed to potentially be exposed to COPCs in groundwater that may be present in an excavated area via incidental ingestion and dermal contact as well as volatilized COPCs via the inhalation of air in excavated areas. Tables 4.4.RME and 4.5.RME present the potential exposure assumptions for the hypothetical future off-Site Highway Construction Worker scenario.

4.5 Hypothetical Future Off-Site Resident Scenario

A hypothetical future off-Site Resident was assumed to be exposed to COPCs in groundwater via ingestion and dermal contact as well as volatilized COPCs via the inhalation of air during a shower. Both a child resident and adult resident were included in the hypothetical off-Site residential scenario at the request of USEPA. Tables 4.4.RME and 4.6.RME present the potential exposure assumptions for the hypothetical future off-Site Resident scenario.

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4.5.1 Determination of Exposure Point Concentrations

USEPA's ProUCL software (version 4.1.00) was used to derive exposure point concentrations (EPCs). The 95th percentile upper confidence limits on the arithmetic mean (95th UCL) were selected as EPCs if sufficient data were present. When insufficient data were available, the maximum concentration was used as the EPC. Derivation of groundwater EPCs is discussed first, followed by air (indoor, trench, excavation, and shower) EPCs.

4.5.1.1 Tire Shop Groundwater EPCs

Data from shallow source area monitoring well OW-02 were assumed to represent the constituent concentrations of groundwater in contact with source material at the Site and were used to estimate the groundwater EPCs that may contribute to COPC concentrations that may be present in tire shop indoor air.

4.5.1.2 Tire Shop Indoor Air EPCs

Indoor air EPCs for the tire shop were estimated by inputting tire shop groundwater EPCs into the Johnson & Ettinger model (USEPA 2004). Based on field observations (March 21, 2011, personal communication Bert Hubbard of Key Environmental, Inc.) application of the Johnson & Ettinger model (USEPA 2004) assumed the tire shop was approximately 30 feet by 75 feet by 10 feet with no interior walls. The depth to groundwater was assumed to be approximately 10 feet below ground surface. The soil in the vicinity of the tire shop was assumed to be a sandy clay. For all other Johnson & Ettinger model parameters, default assumptions were used. The Johnson & Ettinger model inputs and results are included in Appendix A. Table 3.1 presents the EPCs for tire shop indoor air.

4.5.1.3 On-Site Source Entry Point Groundwater EPCs

BTEX and PAH data from shallow source area monitoring well OW-02 were assumed to represent the constituent concentrations of groundwater in contact with source material at the Site and were used to develop direct contact EPCs for potential exposure to constituents in groundwater in utility trenches and construction excavations. Table 3.2 presents the EPCs for on-Site groundwater.

4.5.1.4 Off-Site Highway Construction Groundwater EPCs

BTEX and PAH data from wells in the area of the planned highway construction, were used to develop EPCs for the hypothetical off-Site highway construction scenario evaluated in the uncertainty section. Ninety-five percent UCLs were chosen as the EPCs when a sufficient number of samples with detected concentrations were present. Otherwise the maximum concentration was chosen as the EPCs. Table 3.4 presents the EPCs for off-Site groundwater in the vicinity of the hypothetical off-Site highway construction.

4.5.1.5 Hypothetical Off-Site Residential Groundwater EPCs

Maximum concentrations from MW-26, the well closest to current residences were chosen as EPCs for the hypothetical future off-Site residential groundwater scenario. Table 3.6 presents the EPCs for off-Site residential groundwater.

4.5.1.6 On-Site Trench Air EPCs

To develop EPCs for volatile COPCs in on-Site utility trench air and construction excavation air, on-Site groundwater EPCs based on shallow source area monitoring well OW-02 were input into the Virginia Department of Environmental Quality's (VDEQ's) trench model (http://www.deq.virginia.gov/export/sites/default/vrprisk/files/exposure/vrp38.xls). VDEQ and Massachusetts Department of Environmental Protection (MADEP) have both developed models that develop conservative estimates of the concentration of volatile constituents that may be present in a utility trench. VDEQ's model has been updated more recently, October 2007, and was, therefore, chosen for the estimation of potential concentrations of COPCs in trench air and excavation air.

The default assumptions for trench dimensions were used in the model to estimate concentrations of COPCs that may be present in trenches dug by utility workers. Construction workers were assumed to potentially be exposed to COPCs in a larger excavation. The excavation area for the construction worker was assumed to be 100 feet wide by 100 feet long with a depth of 8 feet, which is the default depth. A site-specific air exchange rate was developed for the trench model. The National Climate Data Center (NCDC) reports the average annual wind speed in Houston, Texas to be 7.6 miles per hour (http://www.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html). Using the width of the trench for the utility worker (3 feet), the average wind speed could result in theoretical air exchange of more than once per second. To be conservative and recognizing that complete exchange of all trench air may not occur every time wind passes across the opening of the trench, an exchange rate of once per minute was assumed, equal to an air exchange rate of once per minute or 60 per hour. The larger excavation area assumed for the construction worker results in an air exchange rate of approximately six exchanges per minute and results in air exchange rate of 360 exchanges per hour for the construction worker. Default assumptions were used for all other trench model input parameters. The utility worker trench model and construction worker excavation area model are included in Appendix A. Table 3.3 presents the EPCs for on-Site utility trench air. Table 3.4 presents the EPCs for on-Site construction excavation area air.

4.5.1.7 Off-Site Excavation Air EPCs

EPCs for volatile COPCs in hypothetical off-Site construction excavation air were estimated using the same approach as for on-Site construction excavation with the exception that hypothetical off-Site highway construction groundwater EPCs were used in conjunction with VDEQ's trench model. The excavation model is included in Appendix A. Table 3.5 presents the EPCs for off-Site construction excavation air.

4.5.1.8 Off-Site Shower Air EPCs

Potential exposure to volatile COPCs in the hypothetical residential off-Site shower scenario was estimated by inputting the off-Site residential groundwater EPCs into the Andelman equation as presented by Schaum et al. (Schaum et al. 1994). Default assumptions were used for all input parameters in the shower model. The shower model is included in Appendix A. Table 3.7 presents the EPCs for off-Site hypothetical residential shower air.

4.5.2 Estimation of Chemical Intake

The Chronic Daily Intake (CDI) estimates a receptor's potential daily intake from exposure to COPCs in the media of interest. The equations used to estimate CDIs are presented below. The exposure parameters used to estimate the potential exposure associated with each potential exposure pathway are presented in Tables 4.1.RME through 4.6.RME.

4.5.2.1 Groundwater

Potential direct exposure to COPCs in groundwater was assumed to occur via incidental ingestion and dermal contact. CDIs for groundwater ingestion were estimated using the equations shown below.

$$CDI = \frac{C_{GW} \times IR \times ET \times EF \times ED \times CF}{AT \times BW}$$

where:

CDI	=	Chronic Daily Intake Due to Ingestion (mg/kg-day)
C_{GW}	=	COPC Concentration in Groundwater (mg/L)
IR	=	Ingestion Rate of Groundwater (L/hour)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time (days)

CDIs for dermal absorption of COPCs in groundwater were estimated using the equations shown below.

$$CDI = \frac{DA_{event} \times EV \times ED \times EF \times SA}{AT \times BW}$$

where:

CDI	=	Chronic Daily Intake Due to Dermal Contact (mg/kg-day)

DA_{event}	=	Absorbed Dose (mg/cm^2-event)
EV	=	Event Frequency (events/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
SA	=	Skin Surface Area Available for Contact (cm^2)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

If $t_{event} \bullet t^*$, then:

$$DA_{event} = 2FA \times K_p \times C_{GW} \times CF \times \sqrt{\frac{6\mathrm{T} \times t_{event}}{\Pi}}$$

If $t_{event} > t^*$, then:

$$DA_{event} = FA \times K_p \times C_{GW} \times CF \times \left[\frac{t_{event}}{1+B} + 2\mathrm{T}_{event}\left(\frac{1+3B+3B^2}{(1+B)^2}\right)\right]$$

where:

DA_{event}	=	Absorbed Dose (mg/cm^2-event)
FA	=	Fraction Absorbed of Water (unitless)
K_p	=	Dermal Permeability Coefficient of COPC in Water (cm/hour)
C_{GW}	=	COPC Concentration in Groundwater (mg/L)
CF	=	Conversion Factor (1000 cm^3/L)
$\bullet_{event}$	=	Lag Time per Event (hours/event)
t_{event}	=	Event Duration (hours/event)
t^*	=	Time to Reach Steady-State (hours) = 2.4 $\bullet_{event}$
B	=	Dimensionless Ratio of the Permeability Coefficient of a Compound through the Stratum Corneum Relative to its Permeability Coefficient Across the Epidermis (unitless)

4.5.2.2 Air (Indoor, Trench, Excavation, and Shower)

Exposure to COPCs in air was assumed to occur via inhalation. CDIs for air inhalation were estimated using the equation shown below.

$$CDI = \frac{C_{IA/TA/EA/SA} \times ET \times EF \times ED}{AT}$$

where:

CDI	=	Chronic Daily Intake Due to Inhalation (mg/m^3)

$C_{IA/TA/EA/SA}$	=	COPC Concentration in Indoor Air/Trench Air/Excavation Air/Shower Air (mg/m^3)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
AT	=	Averaging Time (hours)

As discussed previously, the exposure parameters used to estimate potential exposure associated with each potential exposure pathway are presented in Tables 4.1.RME through 4.6.RME for the current on-Site Worker, current/future on-Site Utility Worker, future on-Site Construction Worker, future Highway Construction Worker, and future off-Site Resident, respectively.

5. Toxicity Assessment

The toxicity values used in the HHRA were obtained from the following sources, in order of priority, per USEPA guidance (USEPA 2003):

- Tier 1 – USEPA's Integrated Risk Information System (IRIS) (USEPA 2010a);
- Tier 2 – USEPA's Provisional Peer Review Toxicity Values; and
- Tier 3 – Other toxicity values including those from additional USEPA and non-USEPA sources such as the EPA's Health Effects Assessment Summary Tables (HEAST), and values developed by the Agency for Toxic Substances and Disease Registry (ATSDR) and the California Environmental Protection Agency (CalEPA).

Tables 5.1a, 5.1b, 5.2a, and 5.2b present the chronic and subchronic non-cancer toxicity values, and Tables 6.1 and 6.2 present the cancer toxicity values, which were used in the HHRA. The current/future on-Site utility worker scenario and future on-Site construction worker scenario were assumed to be subchronic exposures and, thus, used the subchronic non-cancer toxicity values. All other scenarios were assumed to potentially be chronic exposures.

Age-dependant adjustment factors were applied to COPCs believed by USEPA to be mutagenic in accordance with USEPA (2005a) guidance. Potentially mutagenic COPCs include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(ah)anthracene, and indeno(123cd)pyrene. However, Beazer does not concur with USEPA's approach for developing age-dependant adjustment factors nor USEPA's application of the approach to potentially carcinogenic PAHs. At the request of USEPA those factors have been used in this HHRA for the evaluation of potential risks to the hypothetical future off-Site child resident but Beazer believes they overstate the potential risks associated with potential exposures during early life stages. In the interest of keeping this HHRA brief, discussion of Beazer's scientifically based concerns regarding these factors is not included in this HHRA. If use of these adjustments results in potential risks that drive the ultimate remedy at this Site, Beazer reserves the right to provide EPA with an alternative interpretation of the need for age-dependent adjustments factors consistent with Beazer's interpretation of the science.

6. Risk Characterization

The conservative estimates of potential cancer and potential non-cancer risks for all receptors potentially exposed to the COPCs from the Site were compared with USEPA's acceptable risk range of $1x10^{-6}$ to $1x10^{-4}$ and target hazard index of 1.0 to determine whether the estimated potential current and potential future risks were within or below USEPA's target risk range and, thus, did not pose an unacceptable risk.

6.1 Current/Future On-Site Worker Scenario

The potential cancer risk for the current on-Site worker is $1x10^{-14}$, which is below USEPA's acceptable risk range. The potential non-cancer risk for the current on-Site Worker is 0.4, which is below USEPA's target hazard index. Table 7.1.RME summarizes the potential risk estimates for the current on-Site Worker scenario.

6.2 Current/Future On-Site Utility Worker Scenario

As noted above, potential ingestion, dermal and inhalation exposure pathways to COPCs in groundwater are incomplete over virtually the entire Site for on-Site utility workers. These potential exposure pathways are only potentially complete at source entry points. The potential cancer risk for the current/future on-Site utility worker potentially exposed to COPCs in shallow groundwater at source entry points is $4x10^{-06}$, which is within USEPA's acceptable risk range. The potential non-cancer risk for the current/future on-Site Utility Worker is 4, which is above USEPA's target hazard index., The potential risks estimated for the utility worker scenario are very unlikely to occur because, as described above, subsurface work at source entry points is precluded by concrete covers and would require US EPA approval. Such approval would almost certainly require use of PPE greatly reducing the potential exposures estimated in this HHRA. The potential risks estimated for this scenario do not account for the reduction or elimination of potential exposures associated with use of PPE. Table 7.2.RME summarizes the potential risk estimates for the current/future on-Site Utility Worker scenario.

6.3 Future On-Site Construction Worker Scenario

As noted above, potential exposure pathways to COPCs in groundwater are incomplete over virtually the entire Site for future on-Site construction workers. These potential exposure pathways are only complete at source entry points. The potential cancer risk for the future on-Site construction worker is $2x10^{-05}$, which is within USEPA's acceptable risk range. The potential non-cancer risk for the future on-Site Construction Worker is 2 which is above USEPA's target hazard index. As with the utility worker scenario, the potential risks estimated for the construction worker scenario are very unlikely to occur because subsurface work at source entry points is precluded by concrete covers, would require US EPA approval, and does not account for the reduction or elimination of potential exposures associated with use of PPE by future construction workers. Table 7.3.RME summarizes the potential risk estimates for the future on-Site Construction Worker scenario.

6.4 Hypothetical Future Off-Site Resident Scenario

The cumulative potential cancer risk for the hypothetical future child and adult off-Site resident is $5x10^{-03}$, which is above USEPA's acceptable risk range. The potential non-cancer risk for the hypothetical future child off-Site resident is 90 and the hypothetical future adult off-Site resident is 90, which are above USEPA's target hazard index. The estimated potential risks associated with the hypothetical future off-site resident scenario are not likely to occur. This scenario assumes that a hypothetical future resident installs a well in the small area encompassed by the off-Site plume and uses that well as a potable water supply. Because a public water supply is available to all residents and is used by all current residents in the vicinity of the Site, installation of a potable well by a resident is very unlikely. Table 7.5.RME summarizes the potential risk estimates for the hypothetical future child off-Site Resident scenario. Table 7.6.RME summarizes the potential risk estimates for the hypothetical future adult off-Site Resident scenario.

7. Uncertainty Analysis

7.1 Data

All data used in the HHRA are more than five years old. Groundwater concentrations likely have continued to decline since the most recent data were collected, thus, the data used here likely represent an overestimate current COPC concentrations at the Site.

7.2 Exposure

The RME exposure assumptions chosen were intentionally selected to represent the high end of the distributions of many of the individual parameters that determine potential exposure at the Site. Selection of several such parameters almost certainly results in an overestimate of actual potential exposures.

7.2.1 Vapor Intrusion Modeling

EPA's J&E model was used to estimate the concentrations of VOCs volatilized from groundwater to indoor air. Site-specific assumptions were used for some of the parameters; however, conservative default assumptions were used most model parameters. As a result, the J&E model likely overestimates COPC concentrations in indoor air and, consequently, also overestimates potential cancer risks and potential noncancer risks. In part, overestimation of potential risks is due to simplifying assumptions employed by the J&E model including:

- A constant, homogenous COPC concentration in groundwater or soil;

- Equilibrium partitioning between dissolved COPCs in groundwater and COPC vapors at the groundwater table;
- Linear equilibrium partitioning within the soil matrix between sorbed, dissolved, and vapor phases, where the partitioning is a function of constant COPC- and soil-specific parameters;
- Steady-state vapor-diffusion and liquid-phase diffusion through the capillary fringe, vadose zone, and foundation cracks;
- No loss of a COPC as it diffuses towards ground surface (e.g., no biodegradation); and,
- Steady, well-mixed dispersion of the emanating vapors within the enclosed space.

Uncertainty is also introduced by the VDEQ model used to model the concentrations of COPCs in trench air and excavation area air. The VDEQ model assumes the COPC concentration in the entire volume of air within the trench or excavation area reaches equilibrium with a concentration in groundwater. Concentrations within the trench or excavation area would be expected to be higher closer to the groundwater-air interface (at the bottom of the trench/excavation) and lower within the breathing space of the receptor which is closer to the top of the trench and subject to substantially greater air exchange. It is possible, if not likely that the air exchange rate for the breathing zone of workers in the trench or excavation area could be higher than the rates assumed by the HHRA, which would also result in a lower concentration within the breathing space of the receptor. Therefore, the concentrations predicted by the VDEQ model are likely an over-estimate of potential exposure.

Uncertainties were also identified for the Schaum et al. (1994) model which was used to estimate indoor air concentrations of COPCs associated with showering in the hypothetical future residential scenario. The Schaum model uses the maximum concentration in groundwater to estimate a concentration in ambient air assuming equilibrium partitioning between the water and air phases. Other than ideal conditions or a closed system, this assumption is expected to overestimate the maximum concentration in the shower. The maximum concentration is then used to estimate potential exposure during both the shower and any time spent in the bathroom after showering. More likely, the concentration of COPCs in bathroom air increases slowly during showering and then decreases after the shower is turned off. Finally volatilization of a COPC from water is a COPC-specific value that is not easily predicted. Although volatilization is dependent on henry's law constant and molecular weight, it is not easily predicted. The assumed volatilization in by the Schaum model in this HHRA (0.9) is at the high end of results reported by Andelman (1990).

7.3 Toxicity

The Toxicity Assessment step of a HHRA always involves uncertainty because the ability of a risk assessor to characterize the dose-response characteristics of a COPC is entirely dependent on that constituent having been previously subjected to rigorous toxicological or epidemiological study by the scientific community. A valid study requires that a suitable number of test organisms were exposed to a constituent, over a suitable range of doses to account for expected exposures in natural settings, and that a suitable number of toxicological end-points were examined in the organisms to ensure that the health effects associated with each dose were well-characterized. Uncertainty arises however, because most laboratory toxicological studies tend to involve the administration of high doses of a single constituent over a short time frame to a non-human organism, whereas humans in natural settings tend to be exposed to low doses of constituent mixtures over a long time frame. Epidemiological studies require a clear identification and understanding of all potential confounding factors that could lead to erroneous conclusions being drawn about the relationship between a constituent and the effects it elicits in an organism, and often these studies are in occupational settings where the doses are much higher than what would occur in non-occupational settings.

The dose-response characteristics of a constituent are most defensible for use in a risk assessment when sufficient toxicological or epidemiological dose-response information exists for USEPA to derive an RfD or CSF. USEPA derives point-estimate RfDs and CSFs by applying conservative assumptions and uncertainty factors to available toxicological or epidemiological dose-response information, in order to account for the limitations of toxicological research outlined above, namely animal-to-human extrapolation, and high-to-low dose extrapolation. A USEPA-derived COPC-specific RfD and/or CSF was used for each of the COPCs in the HHRA. Accordingly, little chance exists that potential risks were underestimated in the risk assessment. It is much more likely that potential risks are overestimated for most COPCs, potentially substantially.

Age-dependant adjustment factors were applied to COPCs believed by USEPA to be mutagenic in accordance with USEPA (2005a) guidance. Beazer does not concur with USEPA's approach for developing age-dependant adjustment factors nor USEPA's application of the approach to potentially carcinogenic PAHs. At the request of USEPA those factors have been used in this HHRA but Beazer believes they overstate the potential risks associated with potential exposures during early life stages.

7.4 Risk Characterization

The combination of conservative estimates of potential exposure with conservative estimates of potential toxicity leads to very conservative estimates of potential risk for all scenarios included in this risk assessment making it very unlikely that potential risks have been underestimated. Rather, it is very likely that the estimates of potential risk presented in this risk assessment substantially overestimate any actual risks, if such are even present.

As described above, potential exposure pathways to COPCs in groundwater are likely to be incomplete for off-Site hypothetical future highway construction workers. Thus, such workers are not likely to be at risk from COPCs in groundwater. However, to be conservative, an evaluation of the potential risks for a hypothetical future off-Site Highway Construction Worker is included in this section. By its nature, this evaluation assumes that the hypothetical future off-site highway construction scenario not only reaches shallow groundwater but actually breaches the layer of clean shallow groundwater and allows deeper groundwater with detectable COPC concentrations to enter the excavation area. Assuming this happens, the potential excess lifetime cancer risk for the hypothetical future off-Site Highway Construction Worker is $8x10^{-5}$, which is within USEPA's acceptable risk range. The potential non-cancer risk for the off-Site Highway Construction Worker is 0.9, which below USEPA's target hazard index. Table 7.4.RME summarizes the potential risk estimates for the hypothetical future off-Site Highway Construction Worker scenario. These estimates of potential risk for the hypothetical future off-site Highway construction worker are conservative not only because the exposure pathways included in the evaluation are likely to be incomplete, but the estimates of potential risk do not account for the dilution of deeper groundwater containing COPCs with shallower groundwater that does not have detectable levels of COPCs. Any contact by an off-site hypothetical construction worker with groundwater in an excavation area will be primarily with shallow groundwater that has nondetectable concentrations of COPCs.

8. Summary of Human Health Risk Assessment

The HHRA assesses current and future potential health risks from concentrations of COPCs in groundwater to people that may work and live on and near the Site. BTEX and PAH data collected from on-Site and off-Site during 1999, 2000, and 2005 were used to estimate potential COPC concentrations in the groundwater.

Potential excess lifetime cancer risks and potential non-cancer risks for the current/future on-Site worker and hypothetical future off-site highway construction worker were below USEPA's benchmarks indicating that unacceptable risks are not present, even when conservative exposure assumptions are used.

Potential excess lifetime cancer risks for current/future on-site utility workers and future on-site construction worker were below USEPA's allowable risk range indicating that unacceptable potential cancer risks are not present. Potential non-cancer risks for current/future on-site utility workers and future on-site construction workers were slightly above USEPA's benchmark. These estimated potential noncancer risks apply only to potential exposures at source entry points. No risks are assumed to be present in areas of the Site outside of source entry points given the absence of complete exposure pathways at such locations. Even for source entry points the potential risks estimated in this HHRA are very conservative because any subsurface utility or construction work would require removal of concrete covers and approval of such work by US EPA. Additionally, the potential risks estimated in this HHRA assume no PPE is used by utility and construction workers. Subsurface work approved by US EPA at source entry points would almost certainly require use of PPE greatly reducing or eliminating the potential risks estimated by the assumptions used in this HHRA.

Potential excess lifetime cancer risks and potential non-cancer risks for hypothetical future residential scenarios were above USEPA's benchmarks but are based on an entirely hypothetical and very unlikely scenario. This scenario assumes that a hypothetical future resident installs a well in the small area encompassed by the off-Site plume and uses that well as a potable water supply. Because a public water supply is available to all residents and is used by all current residents in the vicinity of the Site, installation of a potable well by a resident within a few hundred feet of the Site is very unlikely.

9. References

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TABLES

TABLE 1

SELECTION OF EXPOSURE PATHWAYS

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current and Future	On-Site Groundwater	Indoor Air	Tire Shop	On-Site Worker	Adult	Inhalation	Quantitative	Potentially Complete Pathway
		Groundwater	On-Site Groundwater	Utility Worker		Incidental Ingestion		
						Dermal		
		Trench Air	On-Site Utility Trench			Inhalation		
Future	On-Site Groundwater	Groundwater	On-Site Groundwater	Construction Worker		Incidental Ingestion		
						Dermal		
		Excavation Air	On-Site Construction Excavation			Inhalation		
	Off-Site Groundwater	Groundwater	Off-Site Groundwater	Highway Construction Worker		Incidental Ingestion		
						Dermal		
		Excavation Air	Off-Site Construction Excavation			Inhalation		
		Groundwater	Off-Site Groundwater	Resident	Child & Adult	Ingestion		
						Dermal		
		Shower Water				Inhalation		

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TABLE 2.1

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value	Screening Toxicity Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (5)
On-Site Groundwater		**Volatile Organic Compounds**													
	71-43-2	Benzene	0.016	0.016	mg/L	OW-02(12/14/1999)	1/1	NA	0.016	NA	0.00041 C	NA		Yes	ASL
	100-41-4	Ethylbenzene	0.035	0.035	mg/L	OW-02(12/14/1999)	1/1	NA	0.035	NA	0.0015 C	NA		Yes	ASL
	108-88-3	Toluene	0.049	0.049	mg/L	OW-02(12/14/1999)	1/1	NA	0.049	NA	2.3 N	NA		No	BSL
	108-38-3	m/p-Xylene	0.082	0.082	mg/L	OW-02(12/14/1999)	1/1	NA	0.082	NA	1.2 N	NA		No	BSL
	95-47-6	o-Xylene	0.045	0.045	mg/L	OW-02(12/14/1999)	1/1	NA	0.045	NA	1.2 N	NA		No	BSL
		Polycyclic Aromatic Hydrocarbons													
	91-57-6	2-Methylnaphthalene	0.21	0.21	mg/L	OW-02(12/14/1999)	1/1	NA	0.21	NA	0.15 N	NA		Yes	ASL
	83-32-9	Acenaphthene	0.28	0.28	mg/L	OW-02(12/14/1999)	1/1	NA	0.28	NA	2.2 N	NA		No	BSL
	208-96-8	Acenaphthylene	0.013	0.013	mg/L	OW-02(12/14/1999)	1/1	NA	0.013	NA	NA	NA		No	NTX
	120-12-7	Anthracene	0.032	0.032	mg/L	OW-02(12/14/1999)	1/1	NA	0.032	NA	11 N	NA		No	BSL
	56-55-3	Benzo(a)anthracene	0.0068 J	0.0068 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0068	NA	0.000029 C	NA		Yes	ASL
	50-32-8	Benzo(a)pyrene	0.0049 J	0.0049 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0049	NA	0.0000029 C	NA		Yes	ASL
	205-99-2	Benzo(b)fluoranthene	0.005 J	0.005 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.005	NA	0.000029 C	NA		Yes	ASL
	191-24-2	Benzo(g,h,i)perylene	0.0056 J	0.0056 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0056	NA	NA	NA		No	NTX
	207-08-9	Benzo(k)fluoranthene	0.0041 J	0.0041 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0041	NA	0.00029 C	NA		Yes	ASL
	218-01-9	Chrysene	0.0064 J	0.0064 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0064	NA	0.0029 C	NA		Yes	ASL
	53-70-3	Dibenzo(a,h)anthracene	0.0049 J	0.0049 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0049	NA	0.0000029 C	NA		Yes	ASL
	206-44-0	Fluoranthene	0.056	0.056	mg/L	OW-02(12/14/1999)	1/1	NA	0.056	NA	1.5 N	NA		No	BSL
	86-73-7	Fluorene	0.13	0.13	mg/L	OW-02(12/14/1999)	1/1	NA	0.13	NA	1.5 N	NA		No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	0.0055 J	0.0055 J	mg/L	OW-02(12/14/1999)	1/1	NA	0.0055	NA	0.000029 C	NA		Yes	ASL
	91-20-3	Naphthalene	11 D	11 D	mg/L	OW-02(12/14/1999)	1/1	NA	11	NA	0.00014 C	NA		Yes	ASL
	85-01-8	Phenanthrene	0.19	0.19	mg/L	OW-02(12/14/1999)	1/1	NA	0.19	NA	NA	NA		No	NTX
	129-00-0	Pyrene	0.035	0.035	mg/L	OW-02(12/14/1999)	1/1	NA	0.035	NA	1.1 N	NA		No	BSL

Footnotes:

(1) J - Concentration estimated below the detection limit.

E - Concentrations exceed the calibration range of the instrument for the analysis.

(2) Maximum concentration used for screening.

(3) USEPA Regional Screening Levels for tapwater. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

C - Screening level based on cancer toxicity endpoint.

N - Screening level based on noncancer toxicity endpoint.

(5) ASL - Maximum concentration is above screening level.

BSL - Maximum concentration is below screening level.

NTX - No toxicity data is available for the constituent and therefore is not evaluated quantitatively.

TABLE 2.2

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value	Screening Toxicity Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
		Volatile Organic Compounds													
Off-Site Residential Groundwater	71-43-2	Benzene	ND	ND	mg/L		0/1	0.1 - 0.1	ND	NA	0.00041 C	NA		No	ND
	100-41-4	Ethylbenzene	0.0044	0.0044	mg/L	MW-26 (7/5/2000)	1/2	0.5 - 0.5	0.0044	NA	0.0015 C	NA		Yes	ASL
	108-88-3	Toluene	0.00045 J	0.00045 J	mg/L	MW-26 (7/5/2000)	1/2	0.5 - 0.5	0.00045	NA	2.3 N	NA		No	BSL
	108-38-3	m/p-Xylene	0.0066	0.0066	mg/L	MW-26 (7/5/2000)	1/2	0.5 - 0.5	0.0066	NA	1.2 N	NA		No	BSL
	95-47-6	o-Xylene	0.0014	0.0014	mg/L	MW-26 (7/5/2000)	1/2	0.5 - 0.5	0.0014	NA	1.2 N	NA		No	BSL
		Polycyclic Aromatic Hydrocarbons													
	91-57-6	2-Methylnaphthalene	0.11	0.25	mg/L	MW-26 (4/17/2000)	2/2	NA	0.25	NA	0.15 N	NA		Yes	ASL
	83-32-9	Acenaphthene	0.25	0.32	mg/L	MW-26 (4/17/2000)	2/2	NA	0.32	NA	2.2 N	NA		No	BSL
	208-96-8	Acenaphthylene	0.0012 J	0.0019 J	mg/L	MW-26 (4/17/2000)	2/2	NA	0.0019	NA	NA	NA		No	NTX
	120-12-7	Anthracene	0.022	0.028	mg/L	MW-26 (4/17/2000)	2/2	NA	0.028	NA	11 N	NA		No	BSL
	56-55-3	Benzo(a)anthracene	0.0013 J	0.0019 J	mg/L	MW-26 (4/17/2000)	2/2	NA	0.0019	NA	0.000029 C	NA		Yes	ASL
	50-32-8	Benzo(a)pyrene	0.00066 J	0.00066 J	mg/L	MW-26 (4/17/2000)	1/2	0.01 - 0.01	0.00066	NA	0.0000029 C	NA		Yes	ASL
	205-99-2	Benzo(b)fluoranthene	0.00073 J	0.00073 J	mg/L	MW-26 (4/17/2000)	1/2	0.01 - 0.01	0.00073	NA	0.000029 C	NA		Yes	ASL
	191-24-2	Benzo(g,h,i)perylene	ND	ND	mg/L		0/1	0.01 - 0.01	ND	NA	NA	NA		No	ND
	207-08-9	Benzo(k)fluoranthene	ND	ND	mg/L		0/2	0.01 - 0.01	ND	NA	0.00029 C	NA		No	ND
	218-01-9	Chrysene	0.0012 J	0.0023 J	mg/L	MW-26 (4/17/2000)	2/2	NA	0.0023	NA	0.0029 C	NA		No	BSL
	53-70-3	Dibenzo(a,h)anthracene	ND	ND	mg/L		0/2	0.01 - 0.01	ND	NA	0.0000029 C	NA		No	ND
	206-44-0	Fluoranthene	0.029	0.042	mg/L	MW-26 (4/17/2000)	2/2	NA	0.042	NA	1.5 N	NA		No	BSL
	86-73-7	Fluorene	0.15	0.22	mg/L	MW-26 (4/17/2000)	2/2	NA	0.22	NA	1.5 N	NA		No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	ND	ND	mg/L		0/2	0.01 - 0.01	ND	NA	0.000029 C	NA		No	ND
	91-20-3	Naphthalene	1.7	1.7	mg/L	MW-26 (9/19/2005)	1/1	NA	1.7	NA	0.00014 C	NA		Yes	ASL
	85-01-8	Phenanthrene	0.27	0.33	mg/L	MW-26 (4/17/2000)	2/2	NA	0.33	NA	NA	NA		No	BSL
	129-00-0	Pyrene	0.015	0.026	mg/L	MW-26 (4/17/2000)	2/2	NA	0.026	NA	1.1 N	NA		No	BSL

Footnotes:

(1) J - Concentration estimated below the detection limit.

(2) Maximum concentration used for screening.

(3) USEPA Regional Screening Levels for tapwater. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

C - Screening level based on cancer toxicity endpoint.

N - Screening level based on noncancer toxicity endpoint.

(4) ASL - Maximum concentration is above screening level.

BSL - Maximum concentration is below screening level.

NTX - No toxicity data is available for the constituent and therefore is not evaluated quantitatively.

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TABLE 2.3

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum Concentration (Qualifier) (1)	Maximum Concentration (Qualifier) (1)	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (2)	Background Value	Screening Toxicity Value (N/C) (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag (Y/N)	Rationale for Selection or Deletion (4)
Off-Site Highway Groundwater		**Volatile Organic Compounds**													
	71-43-2	Benzene	0.00013 J	0.00034 J	mg/L	TW-2-1 (9/17/2005)	2/9	0.001 - 0.001	0.00034	NA	0.00041 C	NA		Yes	ASL
	100-41-4	Ethylbenzene	0.00014 J	0.064	mg/L	DPS-TN1(12/8/1999)	7/15	0.001 - 0.5	0.064	NA	0.0015 C	NA		Yes	ASL
	108-88-3	Toluene	0.00045 J	0.0054	mg/L	DPS-L1(12/9/1999)	3/15	0.001 - 0.5	0.0054	NA	2.3 N	NA		No	BSL
	108-38-3	m/p-Xylene	0.00033 J	0.061	mg/L	DPS-TN1(12/8/1999)	7/15	0.001 - 0.5	0.061	NA	1.2 N	NA		No	BSL
	95-47-6	o-Xylene	0.00016 JB	0.026	mg/L	DPS-L1(12/9/1999)	6/15	0.001 - 0.5	0.026	NA	1.2 N	NA		No	BSL
		Polycyclic Aromatic Hydrocarbons													
	91-57-6	2-Methylnaphthalene	0.00051 J	0.69 J	mg/L	DPS-TN1(12/8/1999)	12/15	0.01 - 0.01	0.69	NA	0.15 N	NA		Yes	ASL
	83-32-9	Acenaphthene	0.00031 J	0.32	mg/L	L1(12/9/1999),MW-26(4/17/2000)	14/15	5 - 5	0.32	NA	2.2 N	NA		No	BSL
	208-96-8	Acenaphthylene	0.0007 J	0.0019 J	mg/L	MW-26(4/17/2000)	3/15	0.01 - 5	0.0019	NA	NA	NA		No	NTX
	120-12-7	Anthracene	0.00053 J	0.028	mg/L	MW-26(4/17/2000)	10/15	0.01 - 5	0.028	NA	11 N	NA		No	BSL
	56-55-3	Benzo(a)anthracene	0.00035 J	0.0019 J	mg/L	MW-26(4/17/2000)	3/15	0.01 - 5	0.0019	NA	0.000029 C	NA		Yes	ASL
	50-32-8	Benzo(a)pyrene	0.00066 J	0.00071 J	mg/L	DPS-TS3(12/8/1999)	2/15	0.01 - 5	0.00071	NA	0.0000029 C	NA		Yes	ASL
	205-99-2	Benzo(b)fluoranthene	0.00073 J	0.00073 J	mg/L	MW-26(4/17/2000)	1/15	0.01 - 5	0.00073	NA	0.000029 C	NA		Yes	ASL
	191-24-2	Benzo(g,h,i)perylene	0.001 J	0.0033 J	mg/L		4/15	0.01 - 0.01	0.0033	NA	NA	NA		No	NTX
	207-08-9	Benzo(k)fluoranthene	ND	ND	mg/L		0/15	0.01 - 5	ND	NA	0.00029 C	NA		No	ND
	218-01-9	Chrysene	0.0012 J	0.0023 J	mg/L	MW-26(4/17/2000)	2/15	0.01 - 5	0.0023	NA	0.0029 C	NA		No	BSL
	53-70-3	Dibenzo(a,h)anthracene	0.001 J	0.0029 J	mg/L	MW-08(12/14/1999)	4/15	0.01 - 5	0.0029	NA	0.0000029 C	NA		Yes	ASL
	206-44-0	Fluoranthene	0.00037 J	0.042	mg/L	MW-26(4/17/2000)	10/15	0.01 - 5	0.042	NA	1.5 N	NA		No	BSL
	86-73-7	Fluorene	0.012	0.22	mg/L	MW-26(4/17/2000)	10/15	0.01 - 5	0.22	NA	1.5 N	NA		No	BSL
	193-39-5	Indeno(1,2,3-cd)pyrene	0.00071 J	0.0029 J	mg/L	MW-08(12/14/1999)	4/15	0.01 - 5	0.0029	NA	0.000029 C	NA		Yes	ASL
	91-20-3	Naphthalene	1.7	1.7	mg/L	MW-26 (9/19/2005)	1/9	0.001 - 0.001	1.7	NA	0.00014 C	NA		Yes	ASL
	85-01-8	Phenanthrene	0.00051 J	0.33	mg/L	MW-26(4/17/2000)	12/15	0.01 - 5	0.33	NA	NA	NA		No	NTX
	129-00-0	Pyrene	0.00072 J	0.026	mg/L	MW-26(4/17/2000)	8/15	0.01 - 5	0.026	NA	1.1 N	NA		No	BSL

Footnotes:

(1) J - Concentration estimated below the detection limit.

(2) Maximum concentration used for screening.

(3) USEPA Regional Screening Levels for tapwater. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

C - Screening level based on cancer toxicity endpoint.

N - Screening level based on noncancer toxicity endpoint.

(4) ASL - Maximum concentration is above screening level.

BSL - Maximum concentration is below screening level.

NTX - No toxicity data is available for the constituent and therefore is not evaluated quantitatively.

TABLE 3.1.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Indoor Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)		Exposure Point Concentration			
							Value	Units	Statistic	Rationale
Tire Shop Indoor Air	**Volatile Organic Compounds**									
	Benzene	mg/m^3	1.91E-05	NA	1.91E-05		1.91E-05	mg/m^3	Maximum	1 samples
	Ethylbenzene	mg/m^3	3.86E-05	NA	3.86E-05		3.86E-05	mg/m^3	Maximum	1 samples
	Polycyclic Aromatic Hydrocarbons									
	2-Methylnaphthalene	mg/m^3	8.76E-05	NA	8.76E-05		8.76E-05	mg/m^3	Maximum	1 samples
	Benzo(a)anthracene	mg/m^3	NA	NA	NA		NA	mg/m^3		
	Benzo(a)pyrene	mg/m^3	NA	NA	NA		NA	mg/m^3		
	Benzo(b)fluoranthene	mg/m^3	1.16E-07	NA	1.16E-07	J	1.16E-07	mg/m^3	Maximum	1 samples
	Benzo(k)fluoranthene	mg/m^3	NA	NA	NA		NA	mg/m^3		
	Chrysene	mg/m^3	4.81E-07	NA	4.81E-07	J	4.81E-07	mg/m^3	Maximum	1 samples
	Dibenzo(a,h)anthracene	mg/m^3	NA	NA	NA		NA	mg/m^3		
	Indeno(1,2,3-cd)pyrene	mg/m^3	NA	NA	NA		NA	mg/m^3	95th UCL	1 samples
	Naphthalene	mg/m^3	4.70E-03	NA	4.70E-03	D	4.70E-03	mg/m^3	Maximum	1 samples

Footnotes:

Data from one well used to derive exposure point concentrations.

NA - Not Available. In accordance with USEPA 2004, indoor air concentrations were not modeled for compounds with a Henry's law constant less than 1 x 10^{-5} atm-m^3/mole.

USEPA 2004. User's Guide for Evaluating Subsurface Vapor Intrustion into Buildings, Office of Emergency and Remedial Response, EPA Contract Number: 68-W-02-33, February 22, 2004.

TABLE 3.2.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)		Exposure Point Concentration			
							Value	Units	Statistic	Rationale
On-Site Groundwater	**Volatile Organic Compounds**									
	Benzene	mg/L	1.60E-02	NA	1.60E-02		1.60E-02	mg/L	Maximum	1 sample
	Ethylbenzene	mg/L	3.50E-02	NA	3.50E-02		3.50E-02	mg/L	Maximum	1 sample
	Polycyclic Aromatic Hydrocarbons									
	2-Methylnaphthalene	mg/L	2.10E-01	NA	2.10E-01		2.10E-01	mg/L	Maximum	1 sample
	Benzo(a)anthracene	mg/L	6.80E-03	NA	6.80E-03	J	6.80E-03	mg/L	Maximum	1 sample
	Benzo(a)pyrene	mg/L	4.90E-03	NA	4.90E-03	J	4.90E-03	mg/L	Maximum	1 sample
	Benzo(b)fluoranthene	mg/L	5.00E-03	NA	5.00E-03	J	5.00E-03	mg/L	Maximum	1 sample
	Benzo(k)fluoranthene	mg/L	4.10E-03	NA	4.10E-03	J	4.10E-03	mg/L	Maximum	1 sample
	Chrysene	mg/L	6.40E-03	NA	6.40E-03	J	6.40E-03	mg/L	Maximum	1 sample
	Dibenzo(a,h)anthracene	mg/L	4.90E-03	NA	4.90E-03	J	4.90E-03	mg/L	Maximum	1 sample
	Indeno(1,2,3-cd)pyrene	mg/L	5.50E-03	NA	5.50E-03	J	5.50E-03	mg/L	Maximum	1 sample
	Naphthalene	mg/L	1.10E+01	NA	1.10E+01	D	1.10E+01	mg/L	Maximum	1 sample

Footnotes:

Data from one well used to derive exposure point concentrations.

TABLE 3.3.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Trench Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)		Exposure Point Concentration			
							Value	Units	Statistic	Rationale
On-Site Utility Trench Air	**Volatile Organic Compounds**									
	Benzene	mg/m^3	4.98E-03	NA	4.98E-03		4.98E-03	mg/m^3	Maximum	1 sample
	Ethylbenzene	mg/m^3	9.39E-03	NA	9.39E-03		9.39E-03	mg/m^3	Maximum	1 sample
	Polycyclic Aromatic Hydrocarbons									
	2-Methylnaphthalene	mg/m^3	4.43E-02	NA	4.43E-02		4.43E-02	mg/m^3	Maximum	1 sample
	Benzo(a)anthracene	mg/m^3	7.66E-05	NA	7.66E-05	J	7.66E-05	mg/m^3	Maximum	1 sample
	Benzo(a)pyrene	mg/m^3	1.88E-05	NA	1.88E-05	J	1.88E-05	mg/m^3	Maximum	1 sample
	Benzo(b)fluoranthene	mg/m^3	6.02E-04	NA	6.02E-04	J	6.02E-04	mg/m^3	Maximum	1 sample
	Benzo(k)fluoranthene	mg/m^3	1.16E-05	NA	1.16E-05	J	1.16E-05	mg/m^3	Maximum	1 sample
	Chrysene	mg/m^3	7.64E-04	NA	7.64E-04	J	7.64E-04	mg/m^3	Maximum	1 sample
	Dibenzo(a,h)anthracene	mg/m^3	2.41E-07	NA	2.41E-07	J	2.41E-07	mg/m^3	Maximum	1 sample
	Indeno(1,2,3-cd)pyrene	mg/m^3	2.86E-05	NA	2.86E-05	J	2.86E-05	mg/m^3	Maximum	1 sample
	Naphthalene	mg/m^3	2.42E+00	NA	2.42E+00	D	2.42E+00	mg/m^3	Maximum	1 sample

Footnotes:

Data from one well used to derive exposure point concentrations.

TABLE 3.4.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Excavation Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)		Exposure Point Concentration			
							Value	Units	Statistic	Rationale
On-Site Construction Excavation Air	**Volatile Organic Compounds**									
	Benzene	mg/m^3	8.31E-04	NA	8.31E-04		8.31E-04	mg/m^3	Maximum	1 sample
	Ethylbenzene	mg/m^3	1.56E-03	NA	1.56E-03		1.56E-03	mg/m^3	Maximum	1 sample
	Polycyclic Aromatic Hydrocarbons									
	2-Methylnaphthalene	mg/m^3	7.38E-03	NA	7.38E-03		7.38E-03	mg/m^3	Maximum	1 sample
	Benzo(a)anthracene	mg/m^3	1.28E-05	NA	1.28E-05	J	1.28E-05	mg/m^3	Maximum	1 sample
	Benzo(a)pyrene	mg/m^3	3.13E-06	NA	3.13E-06	J	3.13E-06	mg/m^3	Maximum	1 sample
	Benzo(b)fluoranthene	mg/m^3	1.00E-04	NA	1.00E-04	J	1.00E-04	mg/m^3	Maximum	1 sample
	Benzo(k)fluoranthene	mg/m^3	1.93E-06	NA	1.93E-06	J	1.93E-06	mg/m^3	Maximum	1 sample
	Chrysene	mg/m^3	1.27E-04	NA	1.27E-04	J	1.27E-04	mg/m^3	Maximum	1 sample
	Dibenzo(a,h)anthracene	mg/m^3	4.02E-08	NA	4.02E-08	J	4.02E-08	mg/m^3	Maximum	1 sample
	Indeno(1,2,3-cd)pyrene	mg/m^3	4.77E-06	NA	4.77E-06	J	4.77E-06	mg/m^3	Maximum	1 sample
	Naphthalene	mg/m^3	4.04E-01	NA	4.04E-01	D	4.04E-01	mg/m^3	Maximum	1 sample

Footnotes:

Data from one well used to derive exposure point concentrations.

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TABLE 3.5.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)		Maximum Concentration (Qualifier)		Exposure Point Concentration			
								Value	Units	Statistic	Rationale
Off-Site Highway Groundwater	**Volatile Organic Compounds**										
	Benzene	mg/L	5.94E-03	3.40E-04	95% KM (Percentile Bootstrap) UCL	3.4E-04	J	3.40E-04	mg/L	95th UCL	
	Ethylbenzene	mg/L	2.40E-02	1.64E-02	95% KM (t) UCL	6.4E-02		1.64E-02	mg/L	95th UCL	
	Polycyclic Aromatic Hydrocarbons										
	2-Methylnaphthalene	mg/L	9.79E-02	3.09E-01	95% KM (Chebyshev) UCL	6.9E-01	J	3.09E-01	mg/L	95th UCL	
	Benzo(a)anthracene	mg/L	2.04E-01	1.98E-03	95% KM (t) UCL	1.9E-03		1.90E-03	mg/L	Maximum	
	Benzo(a)pyrene	mg/L	2.04E-01	7.29E-04	95% KM (t) UCL	7.1E-04	J	7.10E-04	mg/L	Maximum	
	Benzo(b)fluoranthene	mg/L	2.04E-01	NA		7.3E-04	J	7.30E-04	mg/L	Maximum	1 detected concentration
	Dibenzo(a,h)anthracene	mg/L	2.03E-01	2.73E-03	95% KM (Percentile Bootstrap) UCL	2.9E-03	J	2.73E-03	mg/L	95th UCL	
	Indeno(1,2,3-cd)pyrene	mg/L	2.03E-01	2.74E-03	95% KM (Percentile Bootstrap) UCL	2.9E-03	J	2.74E-03	mg/L	95th UCL	
	Naphthalene	mg/L	1.89E-01	NA		1.7E+00		1.70E+00	mg/L	Maximum	1 detected concentration

Footnotes:

(1) Pro UCL 4.1.00 used to derive the 95th percentile upper confidence limit on the mean (95% UCL).
95% KM (t) UCL - 95th percentile upper confidence limit based upon Kaplan-Meier estimates using the Student's t-distribution cutoff value.
95% KM (Chebyshev) UCL - 95th percentile upper confidence limit based upon Kaplan-Meier estimates using the Chebyshev inequality.
95% KM (Percentile Bootstrap) UCL - 95th percentile upper confidence limit based upon Kaplan-Meier estimates using the percentile bootstrap method.

TABLE 3.6.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Excavation Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)		Maximum Concentration (Qualifier)		Exposure Point Concentration			
								Value	Units	Statistic	Rationale
Off-Site Construction Excavation Air	**Volatile Organic Compounds**										
	Benzene	mg/m^3	3.08E-04	1.77E-05	95% KM (Percentile Bootstrap) UCL	1.77E-05	J	1.77E-05	mg/m^3	95th UCL	
	Ethylbenzene	mg/m^3	1.07E-03	7.31E-04	95% KM (t) UCL	2.86E-03		7.31E-04	mg/m^3	95th UCL	
	Polycyclic Aromatic Hydrocarbons										
	2-Methylnaphthalene	mg/m^3	3.44E-03	1.09E-02	95% KM (Chebyshev) UCL	2.42E-02	J	1.09E-02	mg/m^3	95th UCL	
	Benzo(a)anthracene	mg/m^3	3.83E-04	3.57E-06	95% KM (t) UCL	3.57E-06		3.57E-06	mg/m^3	95th UCL	
	Benzo(a)pyrene	mg/m^3	1.30E-04	4.53E-07	95% KM (t) UCL	4.53E-07	J	4.53E-07	mg/m^3	95th UCL	
	Benzo(b)fluoranthene	mg/m^3	4.09E-03	NA		1.46E-05	J	1.46E-05	mg/m^3	Maximum	1 detected concentration
	Dibenzo(a,h)anthracene	mg/m^3	1.67E-06	2.38E-08	95% KM (Percentile Bootstrap) UCL	2.38E-08	J	2.38E-08	mg/m^3	95th UCL	
	Indeno(1,2,3-cd)pyrene	mg/m^3	1.76E-04	2.52E-06	95% KM (Percentile Bootstrap) UCL	2.52E-06	J	2.52E-06	mg/m^3	95th UCL	
	Naphthalene	mg/m^3	6.95E-03	NA		6.24E-02		6.24E-02	mg/m^3	Maximum	1 detected concentration

Footnotes:

(1) Pro UCL 4.1.00 used to derive the 95th percentile upper confidence limit on the mean (95% UCL).
95% KM (t) UCL - 95th percentile upper confidence limit based upon Kaplan-Meier estimates using the Student's t-distribution cutoff value.
95% KM (Chebyshev) UCL - 95th percentile upper confidence limit based upon Kaplan-Meier estimates using the Chebyshev inequality.
95% KM (Percentile Bootstrap) UCL - 95th percentile upper confidence limit based upon Kaplan-Meier estimates using the percentile bootstrap method.

TABLE 3.7.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Groundwater

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution) (1)	Maximum Concentration (Qualifier)		Exposure Point Concentration			
							Value	Units	Statistic	Rationale
Off-Site Residential Groundwater	**Volatile Organic Compounds**									
	Ethylbenzene	mg/L	1.27E-01	NA	4.40E-03		4.40E-03	mg/L	Maximum	2 samples
	Polycyclic Aromatic Hydrocarbons									
	2-Methylnaphthalene	mg/L	1.80E-01	NA	2.50E-01		2.50E-01	mg/L	Maximum	2 samples
	Benzo(a)anthracene	mg/L	1.60E-03	NA	1.90E-03	J	1.90E-03	mg/L	Maximum	2 samples
	Benzo(a)pyrene	mg/L	2.83E-03	NA	6.60E-04	J	6.60E-04	mg/L	Maximum	2 samples
	Benzo(b)fluoranthene	mg/L	2.87E-03	NA	7.30E-04	J	7.30E-04	mg/L	Maximum	2 samples
	Naphthalene	mg/L	1.70E+00	NA	2.10E+00		2.10E+00	mg/L	Maximum	2 samples

Footnotes:

Data from one well (sampled twice) used to derive exposure point concentration, therefore the maximum concentration was used as the EPC.

TABLE 3.8.RME

EXPOSURE POINT CONCENTRATION SUMMARY

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Shower Air

Exposure Point	Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL (Distribution)	Maximum Concentration (Qualifier)		Exposure Point Concentration			
							Value	Units	Statistic	Rationale
Off-Site Shower Air	**Volatile Organic Compounds**									
	Ethylbenzene	mg/m^3	1.34E+00	NA	4.64E-02		4.64E-02	mg/m^3	Maximum	2 samples
	Polycyclic Aromatic Hydrocarbons									
	2-Methylnaphthalene	mg/m^3	1.90E+00	NA	2.64E+00		2.64E+00	mg/m^3	Maximum	2 samples
	Benzo(a)anthracene	mg/m^3	1.69E-02	NA	2.00E-02	J	2.00E-02	mg/m^3	Maximum	2 samples
	Benzo(a)pyrene	mg/m^3	2.98E-02	NA	6.96E-03	J	6.96E-03	mg/m^3	Maximum	2 samples
	Benzo(b)fluoranthene	mg/m^3	3.02E-02	NA	7.70E-03	J	7.70E-03	mg/m^3	Maximum	2 samples
	Naphthalene	mg/m^3	1.79E+01	NA	2.21E+01		2.21E+01	mg/m^3	Maximum	2 samples

Footnotes:

Data from one well (sampled twice) used to derive exposure point concentration, therefore the maximum concentration was used as the EPC.

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Indoor Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Inhalation	On-Site Worker	Adult	Tire Shop Indoor Air	C	Concentration in Indoor Air	chemical specific	mg/m^3		Intake (mg/m^3) =
				ET	Exposure Time	8	hours/day	USEPA 2009	C x ET x EF x ED x 1/AT
				EF	Exposure Frequency	250	days/year	5 days/wk, 50 wk/yr	
				ED	Exposure Duration	25	years	USEPA 2009	
				AT - NC	Averaging Time - Noncancer	219000	hours		
				AT - C	Averaging Time - Cancer	613200	hours	USEPA 1997	

Footnotes:

USEPA, 1997 - Exposure Factors Handbook. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/P-95/002F a-c. 1997.

USEPA, 2009 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA-540-R-070-002. January 2009.

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Incidental Ingestion	On-Site Utility Worker	Adult	On-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				IR	Ingestion Rate	0.02	L/day	USEPA 2009	C x IR x EF x ED x 1/BW x 1/AT
				EF	Exposure Frequency	5	days/year		
				ED	Exposure Duration	5	years		
				BW	Body Weight	70	kg	USEPA 1997	
				AT - NC	Averaging Time - Noncancer	365	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 1997	
	On-Site Construction Worker	Adult	On-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				IR	Ingestion Rate	0.02	L/day	USEPA 2009	C x IR x EF x ED x 1/BW x 1/AT
				EF	Exposure Frequency	130	days/year	5 days/wk, 26 wk/yr	
				ED	Exposure Duration	1	years		
				BW	Body Weight	70	kg	USEPA 1997	
				AT - NC	Averaging Time - Noncancer	365	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 1997	
Dermal Contact	On-Site Utility Worker	Adult	On-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				CF	Conversion Factor	1.00E-03	L/cm^3		DA_{event} x EF x ED x EV x SA x 1/BW x 1/AT
				EF	Exposure Frequency	5	days/year		For organic compounds:
				ED	Exposure Duration	5	years		If t_{event} • t*, then DA_{event} =
				EV	Event Frequency	1	events/day		2 FA x K_p x C x CF x • ((6 • $_{event}$ x t_{event}) / •)
				SA	Skin surface area available for con	904	cm^2	Average male & female hands (USEPA 2004)	If t_{event} > t*, then DA_{event} =
				t_{event}	Event Duration	8	hr/event		FA x K_p x C x CF x [t_{event}/(1 + B) + 2 • $_{event}$ x ((1 + 3B + $3B^2$)/$(1+B)^2$)]
				t*	Time to reach steady-state	chemical specific	hr	Table 4.7.RME	
				FA	Fraction absorbed	chemical specific	unitless	Table 4.7.RME	
				K_p	Dermal permeability coefficient	chemical specific	cm/hr	Table 4.7.RME	
				• $_{event}$	Lag time per event	chemical specific	hr/event	Table 4.7.RME	
				B	Ratio of the permeability coefficien	chemical specific	unitless	Table 4.7.RME	
				BW	Body Weight	70	kg	USEPA 1997	
				AT - NC	Averaging Time - Noncancer	1825	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 1997	

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal Contact	On-Site Construction Worker	Adult	On-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				CF	Conversion Factor	1.00E-03	L/cm^3		DA_{event} x EF x ED x EV x SA x 1/BW x 1/AT
				EF	Exposure Frequency	130	days/year	5 days/wk, 26 wk/yr	For organic compounds:
				ED	Exposure Duration	1	years		If t_{event} • t*, then DA_{event} =
				EV	Event Frequency	1	events/day		2 FA x K_p x C x CF x • ((6 • $_{event}$ x t_{event}) / •)
				SA	Skin surface area available for con	904	cm^2	Average male & female hands (USEPA 2004)	If t_{event} > t*, then DA_{event} =
				t_{event}	Event Duration	1	hr/event		FA x K_p x C x CF x [t_{event}/(1 + B) + 2 • $_{event}$ x ((1
				t*	Time to reach steady-state	chemical specific	hr	Table 4.7.RME	+ 3B + $3B^2$)/$(1+B)^2$)]
				FA	Fraction absorbed	chemical specific	unitless	Table 4.7.RME	
				K_p	Dermal permeability coefficient	chemical specific	cm/hr	Table 4.7.RME	
				• $_{event}$	Lag time per event	chemical specific	hr/event	Table 4.7.RME	
				B	Ratio of the permeability coefficien	chemical specific	unitless	Table 4.7.RME	
				BW	Body Weight	70	kg	USEPA 1997	
				AT - NC	Averaging Time - Noncancer	365	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 1997	

Footnotes:

USEPA, 1997 - Exposure Factors Handbook. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/P-95/002F a-c. 1997.

USEPA, 2004 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005. July 2004.

USEPA, 2009 - Exposure Factors Handbook: 2009 Update. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/R-09/052A. July 2009.

TABLE 4.3.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current and Future
Medium: On-Site Groundwater
Exposure Medium: Trench/Excavation Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Inhalation	On-Site Utility Worker	Adult	On-Site Groundwater	C	Concentration in Trench Air	chemical specific	mg/m^3		Intake (mg/m^3) =
				ET	Exposure Time	8	hours/day	USEPA 2009	C x ET x EF x ED x 1/AT
				EF	Exposure Frequency	5	days/year	USEPA 2009	
				ED	Exposure Duration	5	years		
				AT - NC	Averaging Time - Noncancer	43800	hours		
				AT - C	Averaging Time - Cancer	613200	hours	USEPA 1997	
	On-Site Construction Worker	Adult	On-Site Groundwater	C	Concentration in Trench Air	chemical specific	mg/m^3		Intake (mg/m^3) =
				ET	Exposure Time	1	hours/day		C x ET x EF x ED x 1/AT
				EF	Exposure Frequency	130	days/year	USEPA 2009	
				ED	Exposure Duration	1	years		
				AT - NC	Averaging Time - Noncancer	8760	hours		
				AT - C	Averaging Time - Cancer	613200	hours	USEPA 1997	

Footnotes:

USEPA, 1997 - Exposure Factors Handbook. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/P-95/002F a-c. 1997.

USEPA, 2009 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA-540-R-070-002. January 2009.

TABLE 4.4.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Incidental Ingestion	e Highway Construction	Adult	Off-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				IR	Ingestion Rate	0.02	L/day	USEPA 2009	C x IR x EF x ED x 1/BW x 1/AT
				EF	Exposure Frequency	250	days/year	5 days/wk, 50 wk/yr	
				ED	Exposure Duration	5	years		
				BW	Body Weight	70	kg	USEPA 2004	
				AT - NC	Averaging Time - Noncancer	1825	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 2004	
Ingestion	Off-Site Resident	Child	Off-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				IR	Ingestion Rate	1	L/day	USEPA 2009	C x IR x EF x ED x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	USEPA 2004	
				ED	Exposure Duration	6	years	USEPA 2004	
				BW	Body Weight	15	kg	USEPA 2004	
				AT - NC	Averaging Time - Noncancer	2190	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 2004	
	Off-Site Resident	Adult	Off-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				IR	Ingestion Rate	2	L/day	USEPA 2009	C x IR x EF x ED x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	USEPA 2004	
				ED	Exposure Duration	24	years	USEPA 2004	
				BW	Body Weight	70	kg	USEPA 2004	
				AT - NC	Averaging Time - Noncancer	8760	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 2004	
Dermal Contact	Off-Site Highway Construction Worker	Adult	Off-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				CF	Conversion Factor	1.00E-03	L/cm^3		DA_{event} x EF x ED x EV x SA x 1/BW x 1/AT
				EF	Exposure Frequency	250	days/year	5 days/wk, 50 wk/yr	For organic compounds:
				ED	Exposure Duration	5	years		If $t_{event} \bullet t^*$, then DA_{event} =
				EV	Event Frequency	1	events/day		2 FA x K_p x C x CF x • ((6 $\bullet_{event}$ x t_{event}) / •)
				SA	Skin surface area available for con	904	cm^2	Average male & female hands (USEPA 2004)	If $t_{event} > t^*$, then DA_{event} =
				t_{event}	Event Duration	1	hr/event		FA x K_p x C x CF x [$t_{event}/(1 + B) + 2 \bullet_{event}$ x
				t*	Time to reach steady-state	chemical specific	hr	Table 4.7.RME	$((1 + 3B + 3B^2)/(1+B)^2)$]
				FA	Fraction absorbed	chemical specific	unitless	Table 4.7.RME	
				K_p	Dermal permeability coefficient	chemical specific	cm/hr	Table 4.7.RME	
				$\bullet_{event}$	Lag time per event	chemical specific	hr/event	Table 4.7.RME	
				B	Ratio of the permeability coefficien	chemical specific	unitless	Table 4.7.RME	
				BW	Body Weight	70	kg	USEPA 2004	
				AT - NC	Averaging Time - Noncancer	1825	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 2004	

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TABLE 4.4.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Dermal Contact	Off-Site Resident	Child	Off-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				CF	Conversion Factor	1.00E-03	L/cm^3		DA_{event} x EF x ED x EV x SA x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	USEPA 2004	For organic compounds:
				ED	Exposure Duration	6	years	USEPA 2004	If t_{event} • t*, then DA_{event} =
				EV	Event Frequency	1	events/day		2 FA x K_p x C x CF x • ((6 $\bullet_{event}$ x t_{event}) / •)
				SA	Skin surface area available for con	6000	cm^2	USEPA 2004	If t_{event} > t*, then DA_{event} =
				t_{event}	Event Duration	0.25	hr/event		FA x K_p x C x CF x [t_{event}/(1 + B) + 2 $\bullet_{event}$ x
				t*	Time to reach steady-state	chemical specific	hr	Table 4.7.RME	((1 + 3B + 3B^2)/(1+B)^2)]
				FA	Fraction absorbed	chemical specific	unitless	Table 4.7.RME	
				K_p	Dermal permeability coefficient	chemical specific	cm/hr	Table 4.7.RME	
				$\bullet_{event}$	Lag time per event	chemical specific	hr/event	Table 4.7.RME	
				B	Ratio of the permeability coefficien	chemical specific	unitless	Table 4.7.RME	
				BW	Body Weight	15	kg	USEPA 2004	
				AT - NC	Averaging Time - Noncancer	2190	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 2004	
	Off-Site Resident	Adult	Groundwater	C	Concentration in Groundwater	chemical specific	mg/L		Intake (mg/kg-day) =
				CF	Conversion Factor	1.00E-03	L/cm^3		DA_{event} x EF x ED x EV x SA x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	USEPA 2004	For organic compounds:
				ED	Exposure Duration	24	years	USEPA 2004	If t_{event} • t*, then DA_{event} =
				EV	Event Frequency	1	events/day		2 FA x K_p x C x CF x • ((6 $\bullet_{event}$ x t_{event}) / •)
				SA	Skin surface area available for con	18000	cm^2	USEPA 2004	If t_{event} > t*, then DA_{event} =
				t_{event}	Event Duration	0.25	hr/event		FA x K_p x C x CF x [t_{event}/(1 + B) + 2 $\bullet_{event}$ x
				t*	Time to reach steady-state	chemical specific	hr	Table 4.7.RME	((1 + 3B + 3B^2)/(1+B)^2)]
				FA	Fraction absorbed	chemical specific	unitless	Table 4.7.RME	
				K_p	Dermal permeability coefficient	chemical specific	cm/hr	Table 4.7.RME	
				$\bullet_{event}$	Lag time per event	chemical specific	hr/event	Table 4.7.RME	
				B	Ratio of the permeability coefficien	chemical specific	unitless	Table 4.7.RME	
				BW	Body Weight	70	kg	USEPA 2004	
				AT - NC	Averaging Time - Noncancer	8760	days		
				AT - C	Averaging Time - Cancer	25550	days	USEPA 2004	

Footnotes:

USEPA, 2004 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005. July 2004.

USEPA, 2009 - Exposure Factors Handbook: 2009 Update. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/R-09/052A. July 2009.

TABLE 4.5.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Excavation Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Inhalation	Off-Site Highway Construction Worker	Adult	Off-Site Groundwater	C	Concentration in Groundwater	chemical specific	mg/m^3		Intake (mg/m^3) =
				ET	Exposure Time	1	hours/day		C x ET x EF x ED x 1/AT
				EF	Exposure Frequency	250	days/year	USEPA 2009	
				ED	Exposure Duration	5	years		
				AT - NC	Averaging Time - Noncancer	43800	hours		
				AT - C	Averaging Time - Cancer	613200	hours	USEPA 1997	

Footnotes:

USEPA, 1997 - Exposure Factors Handbook. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/P-95/002F a-c. 1997.

USEPA, 2009 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA-540-R-070-002. January 2009.

TABLE 4.6.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Medium: Off-Site Groundwater
Exposure Medium: Shower Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name (1)
Inhalation	Off-Site Resident	Child	Off-Site Groundwater	C	Concentration in Shower Air	chemical specific	mg/m^3		Intake (mg/m^3) =
				ET	Exposure Time	0.25	hours/day		C x ET x EF x ED x 1/AT
				EF	Exposure Frequency	350	days/year	USEPA 2009	
				ED	Exposure Duration	6	years	USEPA 2009	
				AT - NC	Averaging Time - Noncancer	52560	hours		
				AT - C	Averaging Time - Cancer	613200	hours	USEPA 1997	
	Off-Site Resident	Adult	Off-Site Groundwater	C	Concentration in Shower Air	chemical specific	mg/m^3		Intake (mg/m^3) =
				ET	Exposure Time	0.25	hours/day		C x ET x EF x ED x 1/AT
				EF	Exposure Frequency	350	days/year	USEPA 2009	
				ED	Exposure Duration	24	years	USEPA 2009	
				AT - NC	Averaging Time - Noncancer	210240	hours		
				AT - C	Averaging Time - Cancer	613200	hours	USEPA 1997	

Footnotes:

USEPA, 1997 - Exposure Factors Handbook. United States Environmental Protection Agency. National Center for Environmental Assessment. Office of Research and Development. EPA/600/P-95/002F a-c. 1997.

USEPA, 2009 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual. (Part F, Supplemental Guidance for Inhalation Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA-540-R-070-002. January 2009.

TABLE 4.7.RME

INPUTS FOR DERMAL CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

CAS	Chemical of Potential Concern	t*	FA	K_p	$\bullet_{event}$	B
	Volatile Organic Compounds					
71-43-2	Benzene	0.70	1.00	1.49E-02	0.29	0.05
100-41-4	Ethylbenzene	1.01	1.00	4.93E-02	0.42	0.20
	Polycyclic Aromatic Hydrocarbons					
91-57-6	2-Methylnaphthalene	1.60	1.00	9.88E-02	0.67	0.45
56-55-3	Benzo(a)anthracene	8.53	1.00	4.74E-01	2.03	2.75
50-32-8	Benzo(a)pyrene	11.67	1.00	7.01E-01	2.69	4.27
205-99-2	Benzo(b)fluoranthene	12.03	1.00	7.02E-01	2.77	4.29
207-08-9	Benzo(k)fluoranthene	12.11	1.00	7.79E-01	2.77	4.76
218-01-9	Chrysene	8.53	1.00	4.74E-01	2.03	2.75
53-70-3	Dibenzo(a,h)anthracene	17.57	0.60	1.51E+00	3.88	9.68
193-39-5	Indeno(1,2,3-cd)pyrene	16.83	0.60	1.04E+00	3.78	6.65
91-20-3	Naphthalene	1.34	1.00	4.66E-02	0.56	0.20

USEPA, 2004 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005. July 2004.

TABLE 5.1a

NON-CANCER TOXICITY DATA - CHRONIC - ORAL/DERMAL

South Cavalcade Superfund Site, Houston, Texas

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds										
Benzene	chronic	4E-03	mg/kg-day	1	4.0E-03	mg/kg-day	blood	300	IRIS	4/17/2003
Ethylbenzene	chronic	1E-01	mg/kg-day	1	1.0E-01	mg/kg-day	liver, kidney	1000	IRIS	6/1/1991
Polycyclic Aromatic Hydrocarbons										
2-Methylnaphthalene	chronic	4E-03	mg/kg-day	1	4.0E-03	mg/kg-day	lung	1000	IRIS	12/22/2003
Benzo(a)anthracene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Benzo(a)pyrene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Benzo(b)fluoranthene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Benzo(k)fluoranthene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Chrysene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Dibenzo(a,h)anthracene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Indeno(1,2,3-cd)pyrene	chronic	NA	mg/kg-day	1	NA	mg/kg-day				
Naphthalene	chronic	2E-02	mg/kg-day	1	2.0E-02	mg/kg-day	body weight	3000	IRIS	9/17/1998

Footnotes:

(1) USEPA, 2004 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005. July 2004.

IRIS - USEPA's Integrated Risk Information System. http://www.epa.gov/iris/

TABLE 5.1b

NON-CANCER TOXICITY DATA - SUBCHRONIC - ORAL/DERMAL

South Cavalcade Superfund Site, Houston, Texas

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds										
Benzene	subchronic	1E-02	mg/kg-day	1	1.0E-02	mg/kg-day	blood	100	PPRTV	NA
Ethylbenzene	subchronic	5E-02	mg/kg-day	1	5.0E-02	mg/kg-day	liver	1000	PPRTV	NA
Polycyclic Aromatic Hydrocarbons										
2-Methylnaphthalene	subchronic	4E-03	mg/kg-day	1	4.0E-03	mg/kg-day	lung	1000	PPRTV	NA
Benzo(a)anthracene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Benzo(a)pyrene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Benzo(b)fluoranthene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Benzo(k)fluoranthene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Chrysene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Dibenzo(a,h)anthracene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Indeno(1,2,3-cd)pyrene	subchronic	NA	mg/kg-day	1	NA	mg/kg-day				
Naphthalene	subchronic	2E-02	mg/kg-day	1	2.0E-02	mg/kg-day	body weight	3000	chronic RfD	9/17/1998

Footnotes:

(1) USEPA, 2004 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005. July 2004.

PPRTV - USEPA's Provisional Peer Reviewed Toxicity Values for Superfund. http://hhpprtv.ornl.gov/

TABLE 5.2a

NON-CANCER TOXICITY DATA - CHRONIC - INHALATION

South Cavalcade Superfund Site, Houston, Texas

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds							
Benzene	chronic	3E-02	mg/m^3	blood	300	IRIS	4/17/2003
Ethylbenzene	chronic	1E+00	mg/m^3	developmental	300	IRIS	3/1/1991
Polycyclic Aromatic Hydrocarbons							
2-Methylnaphthalene	chronic	NA	mg/m^3				
Benzo(a)anthracene	chronic	NA	mg/m^3				
Benzo(a)pyrene	chronic	NA	mg/m^3				
Benzo(b)fluoranthene	chronic	NA	mg/m^3				
Benzo(k)fluoranthene	chronic	NA	mg/m^3				
Chrysene	chronic	NA	mg/m^3				
Dibenzo(a,h)anthracene	chronic	NA	mg/m^3				
Indeno(1,2,3-cd)pyrene	chronic	NA	mg/m^3				
Naphthalene	chronic	3E-03	mg/m^3	nasal	3000	IRIS	9/17/1998

Footnotes:

IRIS - USEPA's Integrated Risk Information System. http://www.epa.gov/iris/

TABLE 5.2b

NON-CANCER TOXICITY DATA - SUBCHRONIC - INHALATION

South Cavalcade Superfund Site, Houston, Texas

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds							
Benzene	subchronic	8E-02	mg/m^3	blood	100	PPRTV	NA
Ethylbenzene	subchronic	9E+00	mg/m^3	ear	100	PPRTV	NA
Polycyclic Aromatic Hydrocarbons							
2-Methylnaphthalene	subchronic	NA	mg/m^3				
Benzo(a)anthracene	subchronic	NA	mg/m^3				
Benzo(a)pyrene	subchronic	NA	mg/m^3				
Benzo(b)fluoranthene	subchronic	NA	mg/m^3				
Benzo(k)fluoranthene	subchronic	NA	mg/m^3				
Chrysene	subchronic	NA	mg/m^3				
Dibenzo(a,h)anthracene	subchronic	NA	mg/m^3				
Indeno(1,2,3-cd)pyrene	subchronic	NA	mg/m^3				
Naphthalene	subchronic	3E-03	mg/m^3	nasal	3000	chronic RfC	9/17/1998

Footnotes:

PPRTV - USEPA's Provisional Peer Reviewed Toxicity Values for Superfund. http://hhpprtv.ornl.gov/

TABLE 6.1

CANCER TOXICITY DATA -- ORAL/DERMAL

South Cavalcade Superfund Site, Houston, Texas

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal	Absorbed Cancer Slope Factor for Dermal		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units	(1)	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds								
Benzene	5.5E-02	$(mg/kg\text{-}day)^{-1}$	1	5.5E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/9/2000
Ethylbenzene	NC	$(mg/kg\text{-}day)^{-1}$	1	NC	$(mg/kg\text{-}day)^{-1}$	D	IRIS	8/1/1991
Polycyclic Aromatic Hydrocarbons								
2-Methylnaphthalene	NC	$(mg/kg\text{-}day)^{-1}$	1	NC	$(mg/kg\text{-}day)^{-1}$	NA	IRIS	12/22/2003
Benzo(a)anthracene	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1	7.3E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (BaP TEF)	3/1/1994
Benzo(a)pyrene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1	7.3E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	11/1/1994
Benzo(b)fluoranthene	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1	7.3E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (BaP TEF)	3/1/1994
Benzo(k)fluoranthene	7.3E-02	$(mg/kg\text{-}day)^{-1}$	1	7.3E-02	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (BaP TEF)	3/1/1994
Chrysene	7.3E-03	$(mg/kg\text{-}day)^{-1}$	1	7.3E-03	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (BaP TEF)	3/1/1994
Dibenzo(a,h)anthracene	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1	7.3E+00	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (BaP TEF)	3/1/1994
Indeno(1,2,3-cd)pyrene	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1	7.3E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS (BaP TEF)	3/1/1994
Naphthalene	NC	$(mg/kg\text{-}day)^{-1}$	1	NC	$(mg/kg\text{-}day)^{-1}$	C	IRIS	9/17/1998

Footnotes:

(1) USEPA, 2004 - Risk Assessment Guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). United States Environmental Protection Agency. Office of Superfund Remediation and Technology Innovation. EPA/540/R/99/005. July 2004.

IRIS - USEPA's Integrated Risk Information System. http://www.epa.gov/iris/

BaP TEF - Benzo(a)pyrene (BaP) toxicity equivalent factors (TEFs) were applied to the oral cancer slope factor for BaP. TEFs are from USEPA, 1993.

USEPA, 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. United States Environmental Protection Agency. Office of Research and Development. EPA/600/R-93/089. July 1993.

TABLE 6.2

CANCER TOXICITY DATA -- INHALATION

South Cavalcade Superfund Site, Houston, Texas

Chemical of Potential Concern	Unit Risk		Weight of Evidence/ Cancer Guideline Description	Unit Risk : Inhalation CSF	
	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
Volatile Organic Compounds					
Benzene	8E-06	$(ug/m^3)^{-1}$	A	IRIS	1/9/2000
Ethylbenzene	NC	$(ug/m^3)^{-1}$	D	IRIS	8/1/1991
Polycyclic Aromatic Hydrocarbons					
2-Methylnaphthalene	NC	$(ug/m^3)^{-1}$	NA	IRIS	12/22/2003
Benzo(a)anthracene	NC	$(ug/m^3)^{-1}$	B2	IRIS	3/1/1994
Benzo(a)pyrene	NC	$(ug/m^3)^{-1}$	B2	IRIS	11/1/1994
Benzo(b)fluoranthene	NC	$(ug/m^3)^{-1}$	B2	IRIS	3/1/1994
Benzo(k)fluoranthene	NC	$(ug/m^3)^{-1}$	B2	IRIS	3/1/1994
Chrysene	NC	$(ug/m^3)^{-1}$	B2	IRIS	3/1/1994
Dibenzo(a,h)anthracene	NC	$(ug/m^3)^{-1}$	B2	IRIS	3/1/1994
Indeno(1,2,3-cd)pyrene	NC	$(ug/m^3)^{-1}$	B2	IRIS	3/1/1994
Naphthalene	NC	$(ug/m^3)^{-1}$	C	IRIS	9/17/1998

Footnotes:

IRIS - USEPA's Integrated Risk Information System. http://www.epa.gov/iris/

TABLE 7.1.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current/Future
Receptor Population: On-Site Worker
Receptor Age: Adult

Medium	Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Indoor Air	Tire Shop	Inhalation	**Volatile Organic Compounds**												
				Benzene	2E-05	mg/m^3	1.6E-06	mg/m^3	7.8E-06	(ug/m^3)$^{-1}$	1E-14	4.4E-06	mg/m^3	3.0E-02	mg/m^3	1.E-04
				Ethylbenzene	4E-05	mg/m^3	3.1E-06	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	8.8E-06	mg/m^3	1.0E+00	mg/m^3	9.E-06
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	9E-05	mg/m^3	7.1E-06	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.0E-05	mg/m^3	NA	mg/m^3	NA
				Benzo(b)fluoranthene	1E-07	mg/m^3	9.5E-09	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.6E-08	mg/m^3	NA	mg/m^3	NA
				Chrysene	5E-07	mg/m^3	3.9E-08	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.1E-07	mg/m^3	NA	mg/m^3	NA
				Indeno(1,2,3-cd)pyrene	NA	mg/m^3	#VALUE!	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	#VALUE!	mg/m^3	NA	mg/m^3	NA
				Naphthalene	5E-03	mg/m^3	3.8E-04	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.1E-03	mg/m^3	3.0E-03	mg/m^3	4.E-01
			Exp. Route Total								1.E-14					4.E-01
		Exposure Point									1.E-14					4.E-01
	Exposure Medium Total										1.E-14					4.E-01
Medium Total											1.E-14					4.E-01
							Total of Receptor Risks Across All Media				1.E-14	Total of Receptor Hazards Across All Media				4.E-01

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TABLE 7.2.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Current/Future
Receptor Population: Utility Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	On-Site	Incidental Ingestion	**Volatile Organic Compounds**												
				Benzene	2E-02	mg/L	4E-09	mg/kg-day	5.5E-02	(mg/kg-day)$^{-1}$	2E-10	3.1E-07	mg/kg-day	1.0E-02	mg/kg-day	3.E-05
				Ethylbenzene	4E-02	mg/L	1E-08	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	6.8E-07	mg/kg-day	5.0E-02	mg/kg-day	1.E-05
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	2E-01	mg/L	6E-08	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	4.1E-06	mg/kg-day	4.0E-03	mg/kg-day	1.E-03
				Benzo(a)anthracene	7E-03	mg/L	2E-09	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-09	1.3E-07	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	5E-03	mg/L	1E-09	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-08	9.6E-08	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	5E-03	mg/L	1E-09	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-09	9.8E-08	mg/kg-day	NA	mg/kg-day	NA
				Benzo(k)fluoranthene	4E-03	mg/L	1E-09	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	8E-11	8.0E-08	mg/kg-day	NA	mg/kg-day	NA
				Chrysene	6E-03	mg/L	2E-09	mg/kg-day	7.3E-03	(mg/kg-day)$^{-1}$	1E-11	1.3E-07	mg/kg-day	NA	mg/kg-day	NA
				Dibenzo(a,h)anthracene	5E-03	mg/L	1E-09	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-08	9.6E-08	mg/kg-day	NA	mg/kg-day	NA
				Indeno(1,2,3-cd)pyrene	6E-03	mg/L	2E-09	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-09	1.1E-07	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	1E+01	mg/L	3E-06	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	2.2E-04	mg/kg-day	2.0E-02	mg/kg-day	1.E-02
			Exp. Route Total								2.E-08					1.E-02
			Dermal Contact	**Volatile Organic Compounds**												
				Benzene	2E-02	mg/L	2.7E-08	mg/kg-day	5.5E-02	(mg/kg-day)$^{-1}$	1E-09	3.8E-07	mg/kg-day	1.0E-02	mg/kg-day	4.E-05
				Ethylbenzene	4E-02	mg/L	2.1E-07	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	2.9E-06	mg/kg-day	5.0E-02	mg/kg-day	6.E-05
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	2E-01	mg/L	3.1E-06	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	4.4E-05	mg/kg-day	4.0E-03	mg/kg-day	1.E-02
				Benzo(a)anthracene	7E-03	mg/L	1.6E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-07	2.2E-06	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	5E-03	mg/L	2.0E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-06	2.8E-06	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	5E-03	mg/L	2.0E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-07	2.9E-06	mg/kg-day	NA	mg/kg-day	NA
				Benzo(k)fluoranthene	4E-03	mg/L	1.9E-07	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	1E-08	2.6E-06	mg/kg-day	NA	mg/kg-day	NA
				Chrysene	6E-03	mg/L	1.5E-07	mg/kg-day	7.3E-03	(mg/kg-day)$^{-1}$	1E-09	2.1E-06	mg/kg-day	NA	mg/kg-day	NA
				Dibenzo(a,h)anthracene	5E-03	mg/L	3.1E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	2E-06	4.3E-06	mg/kg-day	NA	mg/kg-day	NA
				Indeno(1,2,3-cd)pyrene	6E-03	mg/L	2.3E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	2E-07	3.3E-06	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	1E+01	mg/L	7.8E-05	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.1E-03	mg/kg-day	2.0E-02	mg/kg-day	5.E-02
			Exp. Route Total								4.E-06					7.E-02
		Exposure Point Total									4.E-06					8.E-02
	Exposure Medium Total										4.E-06					8.E-02
	Trench Air	On-Site	Inhalation	**Volatile Organic Compounds**												
				Benzene	5E-03	mg/m^3	1.6E-06	mg/m^3	7.8E-06	(ug/m^3)$^{-1}$	1E-14	2.3E-05	mg/m^3	8.0E-02	mg/m^3	3.E-04
				Ethylbenzene	9E-03	mg/m^3	3.1E-06	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	4.3E-05	mg/m^3	9.0E+00	mg/m^3	5.E-06
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	4E-02	mg/m^3	1.4E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.0E-04	mg/m^3	NA	mg/m^3	NA
				Benzo(a)anthracene	8E-05	mg/m^3	2.5E-08	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	3.5E-07	mg/m^3	NA	mg/m^3	NA
				Benzo(a)pyrene	2E-05	mg/m^3	6.1E-09	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	8.6E-08	mg/m^3	NA	mg/m^3	NA
				Benzo(b)fluoranthene	6E-04	mg/m^3	2.0E-07	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.7E-06	mg/m^3	NA	mg/m^3	NA
				Benzo(k)fluoranthene	1E-05	mg/m^3	3.8E-09	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	5.3E-08	mg/m^3	NA	mg/m^3	NA
				Chrysene	8E-04	mg/m^3	2.5E-07	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	3.5E-06	mg/m^3	NA	mg/m^3	NA
				Dibenzo(a,h)anthracene	2E-07	mg/m^3	7.9E-11	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.1E-09	mg/m^3	NA	mg/m^3	NA
				Indeno(1,2,3-cd)pyrene	3E-05	mg/m^3	9.3E-09	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.3E-07	mg/m^3	NA	mg/m^3	NA
				Naphthalene	2E+00	mg/m^3	7.9E-04	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.1E-02	mg/m^3	3.0E-03	mg/m^3	4.E+00
			Exp. Route Total								1.E-14					4.E+00
		Exposure Point Total									1.E-14					4.E+00
	Exposure Medium Total										1.E-14					4.E+00
Medium Total											1.E-14					4.E+00
										Total of Receptor Risks Across All Media	4.E-06				Total of Receptor Hazards Across All Media	4.E+00

TABLE 7.3.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	On-Site	Incidental Ingestion	**Volatile Organic Compounds**												
				Benzene	2E-02	mg/L	2E-08	mg/kg-day	5.5E-02	(mg/kg-day)$^{-1}$	1E-09	1.6E-06	mg/kg-day	1.0E-02	mg/kg-day	2.E-04
				Ethylbenzene	4E-02	mg/L	5E-08	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	3.6E-06	mg/kg-day	5.0E-02	mg/kg-day	7.E-05
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	2E-01	mg/L	3E-07	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	2.1E-05	mg/kg-day	4.0E-03	mg/kg-day	5.E-03
				Benzo(a)anthracene	7E-03	mg/L	1E-08	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	7E-09	6.9E-07	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	5E-03	mg/L	7E-09	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	5E-08	5.0E-07	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	5E-03	mg/L	7E-09	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	5E-09	5.1E-07	mg/kg-day	NA	mg/kg-day	NA
				Benzo(k)fluoranthene	4E-03	mg/L	6E-09	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	4E-10	4.2E-07	mg/kg-day	NA	mg/kg-day	NA
				Chrysene	6E-03	mg/L	9E-09	mg/kg-day	7.3E-03	(mg/kg-day)$^{-1}$	7E-11	6.5E-07	mg/kg-day	NA	mg/kg-day	NA
				Dibenzo(a,h)anthracene	5E-03	mg/L	7E-09	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	5E-08	5.0E-07	mg/kg-day	NA	mg/kg-day	NA
				Indeno(1,2,3-cd)pyrene	6E-03	mg/L	8E-09	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	6E-09	5.6E-07	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	1E+01	mg/L	2E-05	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.1E-03	mg/kg-day	2.0E-02	mg/kg-day	6.E-02
			Exp. Route								1.E-07					6.E-02
			Dermal Contact	**Volatile Organic Compounds**												
				Benzene	2E-02	mg/L	3.7E-08	mg/kg-day	5.5E-02	(mg/kg-day)$^{-1}$	2E-09	2.6E-06	mg/kg-day	1.0E-02	mg/kg-day	3.E-04
				Ethylbenzene	4E-02	mg/L	2.0E-07	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.4E-05	mg/kg-day	5.0E-02	mg/kg-day	3.E-04
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	2E-01	mg/L	3.1E-06	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	2.2E-04	mg/kg-day	4.0E-03	mg/kg-day	5.E-02
				Benzo(a)anthracene	7E-03	mg/L	8.3E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	6E-07	5.8E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	5E-03	mg/L	1.0E-06	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	7E-06	7.2E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	5E-03	mg/L	1.1E-06	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	8E-07	7.4E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(k)fluoranthene	4E-03	mg/L	9.7E-07	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	7E-08	6.8E-05	mg/kg-day	NA	mg/kg-day	NA
				Chrysene	6E-03	mg/L	7.8E-07	mg/kg-day	7.3E-03	(mg/kg-day)$^{-1}$	6E-09	5.5E-05	mg/kg-day	NA	mg/kg-day	NA
				Dibenzo(a,h)anthracene	5E-03	mg/L	1.6E-06	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-05	1.1E-04	mg/kg-day	NA	mg/kg-day	NA
				Indeno(1,2,3-cd)pyrene	6E-03	mg/L	1.2E-06	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	9E-07	8.5E-05	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	1E+01	mg/L	7.0E-05	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	4.9E-03	mg/kg-day	2.0E-02	mg/kg-day	2.E-01
			Exp. Route								2.E-05					3.E-01
		Exposure Point									2.E-05					4.E-01
	Exposure Medium Total										2.E-05					4.E-01
	Excavation Air	On-Site	Inhalation	**Volatile Organic Compounds**												
				Benzene	8E-04	mg/m^3	1.8E-07	mg/m^3	7.8E-06	(ug/m^3)$^{-1}$	1E-15	1.2E-05	mg/m^3	8.0E-02	mg/m^3	2.E-04
				Ethylbenzene	2E-03	mg/m^3	3.3E-07	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.3E-05	mg/m^3	9.0E+00	mg/m^3	3.E-06
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	7E-03	mg/m^3	1.6E-06	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.1E-04	mg/m^3	NA	mg/m^3	NA
				Benzo(a)anthracene	1E-05	mg/m^3	2.7E-09	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.9E-07	mg/m^3	NA	mg/m^3	NA
				Benzo(a)pyrene	3E-06	mg/m^3	6.6E-10	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	4.6E-08	mg/m^3	NA	mg/m^3	NA
				Benzo(b)fluoranthene	1E-04	mg/m^3	2.1E-08	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.5E-06	mg/m^3	NA	mg/m^3	NA
				Benzo(k)fluoranthene	2E-06	mg/m^3	4.1E-10	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.9E-08	mg/m^3	NA	mg/m^3	NA
				Chrysene	1E-04	mg/m^3	2.7E-08	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	1.9E-06	mg/m^3	NA	mg/m^3	NA
				Dibenzo(a,h)anthracene	4E-08	mg/m^3	8.5E-12	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	6.0E-10	mg/m^3	NA	mg/m^3	NA
				Indeno(1,2,3-cd)pyrene	5E-06	mg/m^3	1.0E-09	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	7.1E-08	mg/m^3	NA	mg/m^3	NA
				Naphthalene	4E-01	mg/m^3	8.6E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	6.0E-03	mg/m^3	3.0E-03	mg/m^3	2.E+00
			Exp. Route								1.E-15					2.E+00
		Exposure Point									1.E-15					2.E+00
	Exposure Medium Total										1.E-15					2.E+00
Medium Total											1.E-15					2.E+00
										Total of Receptor Risks Across All Media	2.E-05				Total of Receptor Hazards Across All Media	2.E+00

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TABLE 7.4.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Receptor Population: Highway Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Off-Site	Incidental Ingestion	**Volatile Organic Compounds**												
				Benzene	3E-04	mg/L	5E-09	mg/kg-day	5.5E-02	$(mg/kg\text{-}day)^{-1}$	3E-10	6.7E-08	mg/kg-day	4.0E-03	mg/kg-day	2.E-05
				Ethylbenzene	2E-02	mg/L	2E-07	mg/kg-day	NC	$(mg/kg\text{-}day)^{-1}$	NA	3.2E-06	mg/kg-day	1.0E-01	mg/kg-day	3.E-05
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E-01	mg/L	4E-06	mg/kg-day	NC	$(mg/kg\text{-}day)^{-1}$	NA	6.1E-05	mg/kg-day	4.0E-03	mg/kg-day	2.E-02
				Benzo(a)anthracene	2E-03	mg/L	3E-08	mg/kg-day	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2E-08	3.7E-07	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	7E-04	mg/L	1E-08	mg/kg-day	7.3E+00	$(mg/kg\text{-}day)^{-1}$	7E-08	1.4E-07	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	7E-04	mg/L	1E-08	mg/kg-day	7.3E-01	$(mg/kg\text{-}day)^{-1}$	7E-09	1.4E-07	mg/kg-day	NA	mg/kg-day	NA
				Dibenzo(a,h)anthracene	3E-03	mg/L	4E-08	mg/kg-day	7.3E+00	$(mg/kg\text{-}day)^{-1}$	3E-07	5.3E-07	mg/kg-day	NA	mg/kg-day	NA
				Indeno(1,2,3-cd)pyrene	3E-03	mg/L	4E-08	mg/kg-day	7.3E-01	$(mg/kg\text{-}day)^{-1}$	3E-08	5.4E-07	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	2E+00	mg/L	2E-05	mg/kg-day	NC	$(mg/kg\text{-}day)^{-1}$	NA	3.3E-04	mg/kg-day	2.0E-02	mg/kg-day	2.E-02
			Exp. Route Total								4.E-07					3.E-02
			Dermal Contact	**Volatile Organic Compounds**												
				Benzene	3E-04	mg/L	7.5E-09	mg/kg-day	5.5E-02	$(mg/kg\text{-}day)^{-1}$	4E-10	1.0E-07	mg/kg-day	4.0E-03	mg/kg-day	3.E-05
				Ethylbenzene	2E-02	mg/L	9.1E-07	mg/kg-day	NC	$(mg/kg\text{-}day)^{-1}$	NA	1.3E-05	mg/kg-day	1.0E-01	mg/kg-day	1.E-04
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E-01	mg/L	4.4E-05	mg/kg-day	NC	$(mg/kg\text{-}day)^{-1}$	NA	6.1E-04	mg/kg-day	4.0E-03	mg/kg-day	2.E-01
				Benzo(a)anthracene	2E-03	mg/L	2.2E-06	mg/kg-day	7.3E-01	$(mg/kg\text{-}day)^{-1}$	2E-06	3.1E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	7E-04	mg/L	1.4E-06	mg/kg-day	7.3E+00	$(mg/kg\text{-}day)^{-1}$	1E-05	2.0E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	7E-04	mg/L	1.5E-06	mg/kg-day	7.3E-01	$(mg/kg\text{-}day)^{-1}$	1E-06	2.1E-05	mg/kg-day	NA	mg/kg-day	NA
				Dibenzo(a,h)anthracene	3E-03	mg/L	8.5E-06	mg/kg-day	7.3E+00	$(mg/kg\text{-}day)^{-1}$	6E-05	1.2E-04	mg/kg-day	NA	mg/kg-day	NA
				Indeno(1,2,3-cd)pyrene	3E-03	mg/L	5.8E-06	mg/kg-day	7.3E-01	$(mg/kg\text{-}day)^{-1}$	4E-06	8.1E-05	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	2E+00	mg/L	1.0E-04	mg/kg-day	NC	$(mg/kg\text{-}day)^{-1}$	NA	1.4E-03	mg/kg-day	2.0E-02	mg/kg-day	7.E-02
			Exp. Route Total								8.E-05					2.E-01
		Exposure Point Total									8.E-05					3.E-01
	Exposure Medium Total										8.E-05					3.E-01
	Excavation Air	On-Site	Inhalation	**Volatile Organic Compounds**												
				Benzene	2E-05	mg/m^3	3.6E-08	mg/m^3	7.8E-06	$(ug/m^3)^{-1}$	3E-16	5.0E-07	mg/m^3	3.0E-02	mg/m^3	2.E-05
				Ethylbenzene	7E-04	mg/m^3	1.5E-06	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	2.1E-05	mg/m^3	1.0E+00	mg/m^3	2.E-05
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	1E-02	mg/m^3	2.2E-05	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	3.1E-04	mg/m^3	NA	mg/m^3	NA
				Benzo(a)anthracene	4E-06	mg/m^3	7.3E-09	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	1.0E-07	mg/m^3	NA	mg/m^3	NA
				Benzo(a)pyrene	5E-07	mg/m^3	9.2E-10	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	1.3E-08	mg/m^3	NA	mg/m^3	NA
				Benzo(b)fluoranthene	1E-05	mg/m^3	3.0E-08	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	4.2E-07	mg/m^3	NA	mg/m^3	NA
				Dibenzo(a,h)anthracene	2E-08	mg/m^3	4.9E-11	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	6.8E-10	mg/m^3	NA	mg/m^3	NA
				Indeno(1,2,3-cd)pyrene	3E-06	mg/m^3	5.1E-09	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	7.2E-08	mg/m^3	NA	mg/m^3	NA
				Naphthalene	6E-02	mg/m^3	1.3E-04	mg/m^3	NC	$(ug/m^3)^{-1}$	NA	1.8E-03	mg/m^3	3.0E-03	mg/m^3	6.E-01
			Exp. Route Total								3.E-16					6.E-01
		Exposure Point Total									3.E-16					6.E-01
	Exposure Medium Total										3.E-16					6.E-01
Medium Total											3.E-16					6.E-01
										Total of Receptor Risks Across All Media	8.E-05				Total of Receptor Hazards Across All Media	9.E-01

006275

TABLE 7.5.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Off-Site	Ingestion	**Volatile Organic Compounds**												
				Ethylbenzene	4E-03	mg/L	2E-05	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	2.8E-04	mg/kg-day	1.0E-01	mg/kg-day	3.E-03
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E-01	mg/L	1E-03	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.6E-02	mg/kg-day	4.0E-03	mg/kg-day	4.E+00
				Benzo(a)anthracene	2E-03	mg/L	1E-05	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	4E-05	1.2E-04	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	7E-04	mg/L	4E-06	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-04	4.2E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	7E-04	mg/L	4E-06	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	2E-05	4.7E-05	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	2E+00	mg/L	1E-02	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.3E-01	mg/kg-day	2.0E-02	mg/kg-day	7.E+00
			Exp. Route								2.E-04					1.E+01
			Dermal Contact	**Volatile Organic Compounds**												
				Ethylbenzene	4E-03	mg/L	6.4E-06	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.5E-04	mg/kg-day	1.0E-01	mg/kg-day	1.E-03
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E-01	mg/L	9.2E-04	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	2.1E-02	mg/kg-day	4.0E-03	mg/kg-day	5.E+00
				Benzo(a)anthracene	2E-03	mg/L	1.2E-04	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	5E-04	1.4E-03	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	7E-04	mg/L	6.9E-05	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	3E-03	8.1E-04	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	7E-04	mg/L	7.8E-05	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	3E-04	9.0E-04	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	2E+00	mg/L	6.6E-03	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	7.8E-02	mg/kg-day	2.0E-02	mg/kg-day	4.E+00
			Exp. Route								3.E-03					9.E+00
		Exposure Point									4.E-03					2.E+01
	Exposure Medium Total										4.E-03					2.E+01
	Shower Air	Off-Site	Inhalation	**Volatile Organic Compounds**												
				Ethylbenzene	5E-02	mg/m^3	4.0E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	4.6E-04	mg/m^3	1.0E+00	mg/m^3	5.E-04
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E+00	mg/m^3	2.3E-03	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.6E-02	mg/m^3	NA	mg/m^3	NA
				Benzo(a)anthracene	2E-02	mg/m^3	1.7E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.0E-04	mg/m^3	NA	mg/m^3	NA
				Benzo(a)pyrene	7E-03	mg/m^3	6.0E-06	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	7.0E-05	mg/m^3	NA	mg/m^3	NA
				Benzo(b)fluoranthene	8E-03	mg/m^3	6.6E-06	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	7.7E-05	mg/m^3	NA	mg/m^3	NA
				Naphthalene	2E+01	mg/m^3	1.9E-02	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.2E-01	mg/m^3	3.0E-03	mg/m^3	7.E+01
			Exp. Route								0.E+00					7.E+01
		Exposure Point									0.E+00					7.E+01
	Exposure Medium Total										0.E+00					7.E+01
Medium Total											0.E+00					7.E+01
								Total of Receptor Risks Across All Media			4.E-03	Total of Receptor Hazards Across All Media				9.E+01

006276

TABLE 7.6.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

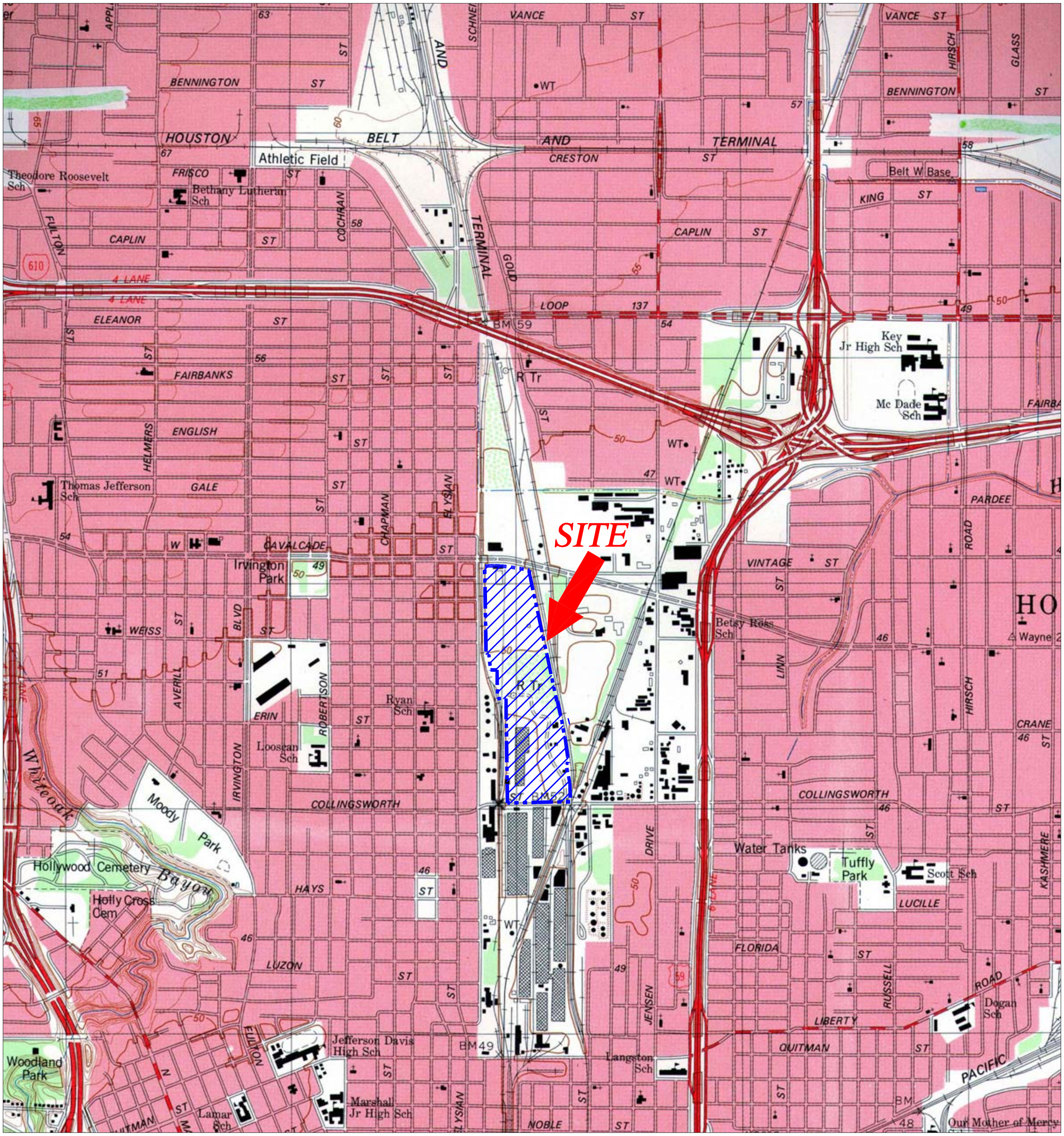
REASONABLE MAXIMUM EXPOSURE

South Cavalcade Superfund Site, Houston, Texas

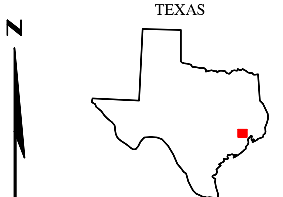
Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Off-Site	Ingestion	**Volatile Organic Compounds**												
				Ethylbenzene	4E-03	mg/L	4E-05	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.2E-04	mg/kg-day	1.0E-01	mg/kg-day	1.E-03
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E-01	mg/L	2E-03	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	6.8E-03	mg/kg-day	4.0E-03	mg/kg-day	2.E+00
				Benzo(a)anthracene	2E-03	mg/L	2E-05	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-05	5.2E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	7E-04	mg/L	6E-06	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	5E-05	1.8E-05	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	7E-04	mg/L	7E-06	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	5E-06	2.0E-05	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	2E+00	mg/L	2E-02	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	5.8E-02	mg/kg-day	2.0E-02	mg/kg-day	3.E+00
			Exp. Route Total								6.E-05					5.E+00
			Dermal Contact	**Volatile Organic Compounds**												
				Ethylbenzene	4E-03	mg/L	1.6E-05	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	9.6E-05	mg/kg-day	1.0E-01	mg/kg-day	1.E-03
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E-01	mg/L	2.4E-03	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	1.4E-02	mg/kg-day	4.0E-03	mg/kg-day	3.E+00
				Benzo(a)anthracene	2E-03	mg/L	3.0E-04	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	2E-04	8.7E-04	mg/kg-day	NA	mg/kg-day	NA
				Benzo(a)pyrene	7E-04	mg/L	1.8E-04	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-03	5.2E-04	mg/kg-day	NA	mg/kg-day	NA
				Benzo(b)fluoranthene	7E-04	mg/L	2.0E-04	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-04	5.8E-04	mg/kg-day	NA	mg/kg-day	NA
				Naphthalene	2E+00	mg/L	1.7E-02	mg/kg-day	NC	(mg/kg-day)$^{-1}$	NA	5.0E-02	mg/kg-day	2.0E-02	mg/kg-day	2.E+00
			Exp. Route Total								2.E-03					6.E+00
		Exposure Point									2.E-03					1.E+01
	Exposure Medium Total										2.E-03					1.E+01
	Shower Air	Off-Site	Inhalation	**Volatile Organic Compounds**												
				Ethylbenzene	5E-02	mg/m^3	1.6E-04	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	4.6E-04	mg/m^3	1.0E+00	mg/m^3	5.E-04
				Polycyclic Aromatic Hydrocarbons												
				2-Methylnaphthalene	3E+00	mg/m^3	9.0E-03	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.6E-02	mg/m^3	NA	mg/m^3	NA
				Benzo(a)anthracene	2E-02	mg/m^3	6.9E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.0E-04	mg/m^3	NA	mg/m^3	NA
				Benzo(a)pyrene	7E-03	mg/m^3	2.4E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	7.0E-05	mg/m^3	NA	mg/m^3	NA
				Benzo(b)fluoranthene	8E-03	mg/m^3	2.6E-05	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	7.7E-05	mg/m^3	NA	mg/m^3	NA
				Naphthalene	2E+01	mg/m^3	7.6E-02	mg/m^3	NC	(ug/m^3)$^{-1}$	NA	2.2E-01	mg/m^3	3.0E-03	mg/m^3	7.E+01
			Exp. Route Total								0.E+00					7.E+01
		Exposure Point									0.E+00					7.E+01
	Exposure Medium Total										0.E+00					7.E+01
Medium Total											0.E+00					7.E+01
									Total of Receptor Risks Across All Media		2.E-03	Total of Receptor Hazards Across All Media				8.E+01

FIGURES



TEXAS



QUADRANGLE LOCATION

BEAZER EAST, INC.
PITTSBURGH, PENNSYLVANIA

DRAWN: BKC	DATE: 4-19-05
CHKD: JRH	DATE: 4-19-05
APPD: JSZ	DATE: 4-19-05
SCALE: 1" = 2000'	

KEY ENVIRONMENTAL INCORPORATED

SOUTH CAVALCADE SUPERFUND SITE
HOUSTON, TEXAS

REFERENCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE OF SETTEGAST, TEXAS – 1982

KEY ENVIRONMENTAL, INC.

ISSUE DATE:

ROSSLYN FARMS
INDUSTRIAL PARK
1200 ARCH ST., SUITE 200
CARNEGIE, PA 15106

SITE LOCATION MAP

DRAWING NUMBER
05-070
FIGURE 1

FILE: G:\CAD\CAVALCAD\98587\FIG-01.DWG

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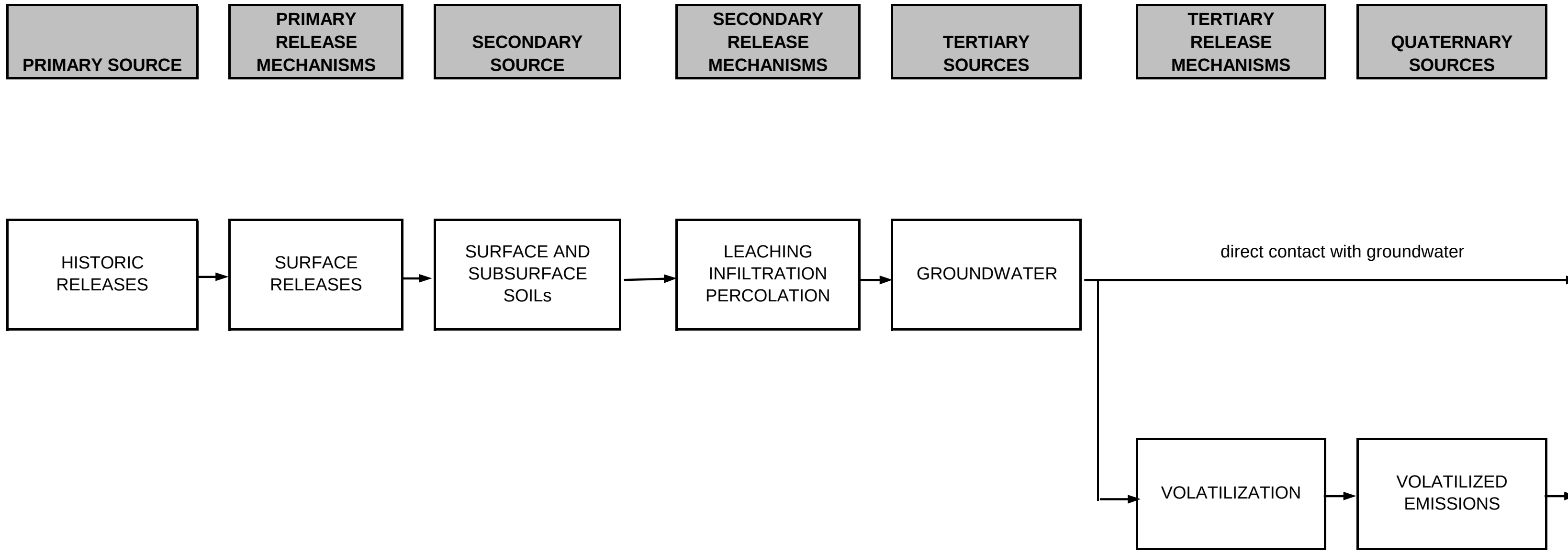
Figure 2
Conceptual Site Model of Potential Groundwater-Related Exposure Pathways
South Cavalcade Superfund Site, Houston, Texas



EXPOSURE ROUTE	POTENTIAL RECEPTORS						
	ON-SITE RECEPTORS				OFF-SITE RECEPTORS		
	On-Site Worker		Construction Worker	Utility Worker	Highway Construction Worker	Off-Site Resident	
	Current	Future	Future	Future	Future	Current	Future
Dermal Absorption	A	A	●	●	B	C	●
Ingestion	A	A	●	●	B	C	●
Inhalation via Showering	A	A	NA	NA	NA	C	●
Inhalation of Indoor Air	●	●	NA	NA	NA	D	D
Inhalation of Trench Air	NA	NA	●	●	B	NA	NA

LEGEND

○ Incomplete Exposure Pathway

● Potentially Complete Exposure Pathway

Notes:
Incomplete Pathways
NA - Not an applicable pathways for that receptor.
A - Consent Orders prohibit the use of on-Site groundwater as potable water, therefore, direct exposure to groundwater is not possible for either current or future on-Site workers.
B - Groundwater with non-detectable concentrations of constituents exists between ground surface and groundwater (at a depth of 16 to 20 ft bgs) with detectable concentrations of constituents. The layer of clean groundwater prevents migration of constituents to potential excavations in off-Site locations. Therefore, no future off-Site potential exposure to constituents via incidental ingestion, dermal contact, or inhalation is possible, however, to be conservative, hypothetical potential risks from exposure to groundwater constituents with detectable concentrations have been evaluated in the uncertainty section (Section 7.4).
C - No current potable water wells exist within the off-site groundwater plume. Therefore, no direct exposure to the current off-site resident exists.
D - Other than at on-Site source entry points, groundwater with non-detectable concentrations of potentially volatile constituents exists between ground surface and groundwater (at a depth of 16 to 20 ft bgs) with detectable concentrations of potentially volatile constituents. The layer of clean groundwater prevents migration of volatiles from groundwater to indoor air in off-Site locations. Therefore, no current or future off-Site exposure to potentially volatile constituents via the vapor intrusion pathway is possible.

Potentially Complete Pathways
Current On-Site worker: The tire shop is above a source entry point and exposure to potentially volatile constituents via the vapor intrusion pathway is possible.
Future On-Site worker: It is possible that a structure could be built in the future above a source entry point. Therefore, potential indoor air exposure via the vapor intrusion pathway is possible for the future on-Site worker within the source entry points, but the pathway is incomplete for the remainder of the Site.
Future On-Site Construction and Utility worker: It is possible that future construction or utility work could occur at a source entry point where either direct contact with constituents in groundwater is possible or where inhalation of potentially volatile constituents in construction or utility trenches is possible. Therefore, these pathways are considered potentially complete for the on-Site construction and utility worker within the source entry points, but the pathway is incomplete for the remainder of the Site.
Future Off-Site Resident: Though a public water supply is available to all residents and is used by current residents, it is possible that a future resident could hypothetically install a well in the small area encompassed by the off-Site plume and be exposed via direct contact to constituents in groundwater. Therefore, direct exposure pathways associated with hypothetical potable water use are considered potentially complete for future off-Site residents.

APPENDIX A
VAPOR INTRUSION MODELS

JOHNSON & ETTINGER MODEL
INDOOR AIR
TIRE SHOP

Table 1. Vapor Intrusion Model Input Parameters for Modeling Groundwater to On-Site Buildings
South Cavalcade Superfund Site, Houston, Texas

Input Parameters	Symbol	Units	USEPA Default Value	Site-Specific Values Developable Area	Notes [a]
Initial Groundwater Concentration	C_g	µg/L	Site-Specific	Chemical-specific	Presented in Table 1 and 3
Geology/Hydrogeology					
Average Soil Temperature	T_S	°C	10	21.1	USEPA (2004)
Depth below grade to bottom of enclosed space floor	L_F	cm	15/200	15	Slab on Grade
Depth below grade to top of water table	Lwt	cm	Site-Specific	305	10 feet to GW
SCS soil type directly above water table			Site-Specific		
Vadose Zone Soil Parameters					
Vadose zone SCS soil type			Site-Specific	Fill (Sand) / Sandy Clay	Site Soil Type, 76 cm / 228.8 cm
Soil Dry Bulk Density	rb^A	g/cm^3	1.66 / 1.63	DV	
Soil Total Porosity	n^A	cm^3/cm^3	0.38 / 0.39	DV	
Air Filled Porosity (intercalcs)	qa, cz	cm^3/cm^3	0.321 / 0.188	DV	
Soil Water-filled Porosity	q_w^A	cm^3/cm^3	0.05 / 0.20	DV	
Building Dimensions					
Enclosed Space Floor Thickness	L_{crack}	cm	10	DV	
Soil-Building Pressure Differential	P	$g/cm\text{-}s^2$	40	DV	
Enclosed Space Floor Length	L_B	cm	1,000	2,286	Tire shop approximately 75' long
Enclosed Space Floor Width	W_B	cm	1,000	914.4	Tire shop approximately 30' wide
Enclosed Space Height	H_B	cm	244 / 366	304.8	Assumed 10-foot ceiling
Floor-wall Seam Crack Width	w	cm	0.1	DV	
Indoor Air Exchange Rate	ER	1/hour	0.25	1	Calculated to be 9, but conservatively assumed to be 1.
Ave. Vapor Flow Rate into Building	Q_{soil}	L/m	5	DV	

Notes:
[a] References and notes for those values different than default
cm = centimeter
°C = degrees Celsius
cm^2 = square centimeter
cm^3/cm^3 = cubic centimeters per cubic centimeter
DV = default value used as input
g/cm^3 = grams per cubic centimeter
$g/cm\text{-}s^2$ = grams per centimeter second squared
J&E = Johnson and Ettinger
L/m = liters per minute
µg/L = micrograms per liter
N/A = not applicable
USEPA 2004 = United States Environmental Protection Agency. User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings. Office of Emergency and Remedial Response. February.

Table 2. Johnson and Ettinger Vapor Intrusion Model Results from Groundwater to Overlying Buildings South Cavalcade Superfund Site, Houston, Texas

Chemical	CAS Number	Maximum Groundwater Concentration and (µg/L)	Estimated Indoor Air Concentration ($\mu g/m^3$)
2-Methylnaphthalene	91576	210	8.8E-02
Benzo(a)anthracene	56553	6.8	NA
Benzo(a)pyrene	50328	4.9	NA
Benzo(b)fluoranthene	205992	5	1.2E-04
Benzo(k)fluoranthene	207089	4.1	NA
Benzene	71432	16	1.9E-02
Chrysene	218019	6.4	4.8E-04
Dibenzo(a,h)anthracene	53703	4.9	NA
Ethylbenzene	100414	35	3.9E-02
Indeno(1,2,3-cd)pyrene	206440	5.5	NA
Naphthalene	91203	11000	4.7E+00

Notes:
µg/L = Micrograms per liter
$\mu g/m^3$ = Micrograms per cubic meter

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
TRENCH MODEL
ON-SITE UTILITY WORKER SCENARIO

Table 1. Model Parameters
Inhalation On-Site Utility Workers in a Trench
Groundwater less than 15 feet deep

For Mass-Transfer Coefficients

Kg,H2O	0.833	cm/s
MWH2O	18	
Kl,O2	0.002	cm/s
MWO2	32	
T	**77**	F
T	298	K
R	8.20E-05	atm-m3/mol-K

For Emission Flux and Concentration in Trench

CF1	1.00E-03	L/cm3
CF2	1.00E+04	cm2/m2
CF3	3600	s/hr
F	**1**	
ACH	60	hr-1

Trench dimensions

Length	**8**	ft
	2.44	m
Width	**3**	ft
	0.91	m
Depth	**8**	ft
	2.44	m
Width/Depth	0.38	

Table 2. On-site exposure-point concentrations (inhalation) for construction/utility workers in a trench: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3	Concentration of Contaminant in Trench Ctrench mg/m3
Benzene	71-43-2	78.11	5.55E-03	5.09E-01	1.28E-03	1.27E-03	1.60E+01	3.12E-01	4.98E+00	4.98E-03
Ethylbenzene	100-41-4	106.17	7.88E-03	4.60E-01	1.10E-03	1.09E-03	3.50E+01	2.68E-01	9.39E+00	9.39E-03
Benzo(a)anthracene	56-55-3	228.29	3.35E-06	3.56E-01	7.49E-04	4.58E-05	6.80E+00	1.13E-02	7.66E-02	7.66E-05
Benzo(a)pyrene	50-32-8	252.31	1.13E-06	3.44E-01	7.12E-04	1.56E-05	4.90E+00	3.83E-03	1.88E-02	1.88E-05
Benzo(b)fluoranthene	205-99-2	252.31	1.11E-04	3.44E-01	7.12E-04	4.89E-04	5.00E+00	1.20E-01	6.02E-01	6.02E-04
Benzo(k)fluoranthene	207-08-9	252.31	8.29E-07	3.44E-01	7.12E-04	1.15E-05	4.10E+00	2.83E-03	1.16E-02	1.16E-05
Chrysene	218-01-9	228.29	9.46E-05	3.56E-01	7.49E-04	4.85E-04	6.40E+00	1.19E-01	7.64E-01	7.64E-04
Dibenzo(a,h)anthracene	53-70-3	278.35	1.47E-08	3.33E-01	6.78E-04	2.00E-07	4.90E+00	4.93E-05	2.41E-04	2.41E-07
Indeno(1,2,3-cd)pyrene	193-39-5	276.33	1.60E-06	3.34E-01	6.81E-04	2.12E-05	5.50E+00	5.21E-03	2.86E-02	2.86E-05
2-Methylnaphthalene	91-57-6	142.20	5.18E-04	4.17E-01	9.49E-04	8.57E-04	2.10E+02	2.11E-01	4.43E+01	4.43E-02
Naphthalene	91-20-3	128.17	4.83E-04	4.32E-01	9.99E-04	8.95E-04	1.10E+04	2.20E-01	2.42E+03	2.42E+00

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
EXCAVATION MODEL
ON-SITE CONSTRUCTION WORKER SCENARIO

Table 1. Model Parameters
Inhalation On-Site Construction Workers in an Excavation
Groundwater less than 15 feet deep

For Mass-Transfer Coefficients

Kg,H2O	0.833	cm/s
MWH2O	18	
Kl,O2	0.002	cm/s
MWO2	32	
T	**77**	F
T	298	K
R	8.20E-05	atm-m3/mol-K

For Emission Flux and Concentration in Trench

CF1	1.00E-03	L/cm3
CF2	1.00E+04	cm2/m2
CF3	3600	s/hr
F	**1**	
ACH	360	hr-1

Trench dimensions

Length	**100**	ft
	30.48	m
Width	**100**	ft
	30.48	m
Depth	**8**	ft
	2.44	m
Width/Depth	12.50	

Table 2. On-site exposure-point concentrations (inhalation) for construction workers in an excavation: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3	Concentration of Contaminant in Trench Ctrench mg/m3
Benzene	71-43-2	78.11	5.55E-03	5.09E-01	1.28E-03	1.27E-03	1.60E+01	5.19E-02	8.31E-01	8.31E-04
Ethylbenzene	100-41-4	106.17	7.88E-03	4.60E-01	1.10E-03	1.09E-03	3.50E+01	4.47E-02	1.56E+00	1.56E-03
Benzo(a)anthracene	56-55-3	228.29	3.35E-06	3.56E-01	7.49E-04	4.58E-05	6.80E+00	1.88E-03	1.28E-02	1.28E-05
Benzo(a)pyrene	50-32-8	252.31	1.13E-06	3.44E-01	7.12E-04	1.56E-05	4.90E+00	6.38E-04	3.13E-03	3.13E-06
Benzo(b)fluoranthene	205-99-2	252.31	1.11E-04	3.44E-01	7.12E-04	4.89E-04	5.00E+00	2.01E-02	1.00E-01	1.00E-04
Benzo(k)fluoranthene	207-08-9	252.31	8.29E-07	3.44E-01	7.12E-04	1.15E-05	4.10E+00	4.71E-04	1.93E-03	1.93E-06
Chrysene	218-01-9	228.29	9.46E-05	3.56E-01	7.49E-04	4.85E-04	6.40E+00	1.99E-02	1.27E-01	1.27E-04
Dibenzo(a,h)anthracene	53-70-3	278.35	1.47E-08	3.33E-01	6.78E-04	2.00E-07	4.90E+00	8.21E-06	4.02E-05	4.02E-08
Indeno(1,2,3-cd)pyrene	193-39-5	276.33	1.60E-06	3.34E-01	6.81E-04	2.12E-05	5.50E+00	8.68E-04	4.77E-03	4.77E-06
2-Methylnaphthalene	91-57-6	142.20	5.18E-04	4.17E-01	9.49E-04	8.57E-04	2.10E+02	3.51E-02	7.38E+00	7.38E-03
Naphthalene	91-20-3	128.17	4.83E-04	4.32E-01	9.99E-04	8.95E-04	1.10E+04	3.67E-02	4.04E+02	4.04E-01

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY
EXCAVATION MODEL
OFF-SITE HIGHWAY CONSTRUCTION WORKER SCENARIO

Table 1. Model Parameters
Inhalation Off-Site Highway Construction Workers in an Excavation
Groundwater less than 15 feet deep

For Mass-Transfer Coefficients

Kg,H2O	0.833	cm/s
MWH2O	18	
Kl,O2	0.002	cm/s
MWO2	32	
T	**77**	F
T	298	K
R	8.20E-05	atm-m3/mol-K

For Emission Flux and Concentration in Trench

CF1	1.00E-03	L/cm3
CF2	1.00E+04	cm2/m2
CF3	3600	s/hr
F	**1**	
ACH	360	hr-1

Trench dimensions

Length	**100**	ft
	30.48	m
Width	**100**	ft
	30.48	m
Depth	**8**	ft
	2.44	m
Width/Depth	12.50	

Table 2. Off-site exposure-point concentrations (inhalation) for highway construction workers in an excavation: Groundwater less than 15 feet deep revised 10/5/07	CAS No.	Molecular Weight MWi g/mol	Henry's Law Constant Hi atm-m3/mol	Gas-Phase Mass Transfer Coefficient KiG cm/s	Liquid-Phase Mass Transfer Coefficient KiL cm/s	Overall Mass Transfer Coefficient Ki cm/s	Concentration of Contaminant in Groundwater Cgw ug/L	Volatilization Factor VF L/m3	Concentration of Contaminant in Trench Ctrench ug/m3	Concentration of Contaminant in Trench Ctrench mg/m3
Benzene	71-43-2	78.11	5.55E-03	5.09E-01	1.28E-03	1.27E-03	3.40E-01	5.19E-02	1.77E-02	1.77E-05
Ethylbenzene	100-41-4	106.17	7.88E-03	4.60E-01	1.10E-03	1.09E-03	1.64E+01	4.47E-02	7.31E-01	7.31E-04
Benzo(a)anthracene	56-55-3	228.29	3.35E-06	3.56E-01	7.49E-04	4.58E-05	1.90E+00	1.88E-03	3.57E-03	3.57E-06
Benzo(a)pyrene	50-32-8	252.31	1.13E-06	3.44E-01	7.12E-04	1.56E-05	7.10E-01	6.38E-04	4.53E-04	4.53E-07
Benzo(b)fluoranthene	205-99-2	252.31	1.11E-04	3.44E-01	7.12E-04	4.89E-04	7.30E-01	2.01E-02	1.46E-02	1.46E-05
Dibenzo(a,h)anthracene	53-70-3	278.35	1.47E-08	3.33E-01	6.78E-04	2.00E-07	2.90E+00	8.21E-06	2.38E-05	2.38E-08
Indeno(1,2,3-cd)pyrene	193-39-5	276.33	1.60E-06	3.34E-01	6.81E-04	2.12E-05	2.90E+00	8.68E-04	2.52E-03	2.52E-06
2-Methylnaphthalene	91-57-6	142.20	5.18E-04	4.17E-01	9.49E-04	8.57E-04	3.09E+02	3.51E-02	1.09E+01	1.09E-02
Naphthalene	91-20-3	128.17	4.83E-04	4.32E-01	9.99E-04	8.95E-04	1.70E+03	3.67E-02	6.24E+01	6.24E-02